SCIENTIFIC AMERICAN SUPPLEMENT No. 821

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Scientific American Supplement, Vol. XXXII. No. 821.
Scientific American, established 1845.

NEW YORK, SEPTEMBER 26, 1891.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

INTERIOR OF THE NEW LABOR EXCHANGE, PARIS.

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THE new Labor Exchange is soon to be inaugurated. We give herewith a view of the entrance facade of the meeting hall. The buildings, which are the work of Mr Bouvard, architect, of the city of Paris, are comprised within the block of houses whose sharp angle forms upon Place de la Republique, the intersection of Boulevard Magenta and Bondy street. One of the entrances of the Exchange is on a level with this street. The three others are on Chateau d'Eau street, where the facade of the edifice extends for a length of one hundred feet. From the facade and above the balcony that projects from the first story, stand out in bold relief three heads surrounded by foliage and fruit that dominate the three entrance doors. These sculptures represent the Republic between Labor and Peace. The windows of the upper stories are set within nine rows of columns, from between the capitals of which stand out the names of the manufacturers, inventors, and statesmen that have sprung from the laboring classes. Upon the same line, at the two extremities of the facade, two modillions, traversed through their center by palms, bear the devices "Labor" and "Peace." Above, there is a dial surmounted by a shield bearing the device of the city of Paris.

The central door of the ground floor opens upon a large vestibule, around which are arranged symmetrically the post, telegraph, telephone, and intelligence offices, etc. Beyond the vestibule there is a gallery that leads to the central court, upon the site of which has been erected the grand assembly hall. This latter, which measures 20 meters in length, 22 in width, and 6 in height, is lighted by a glazed ceiling, and contains ten rows of benches. These latter contain 900 seats, arranged in the form of circular steps, radiating around the president's platform, which is one meter in height. A special combination will permit of increasing the number of seats reserved for the labor associations on occasions of grand reunions to 1,200. The oak doors forming the lateral bays of the hall will open upon the two large assembly rooms and the three waiting rooms constructed around the faces of the large hall. In the assembly rooms forming one with the central hall will take place the deliberations of the syndic chambers. The walls of the hall will, ere long, receive decorative paintings.—*L'Illustration.*

MANUFACTURE OF ROLL TAR PAPER.

ROOFING paper was first used in Scandinavia early as the last century, the invention being accredited to Faxa, an official of the Swedish Admiralty. The first tar and gravel roofs in Sweden were very defective. The impregnation of the paper with a water-proofing liquid had not been thought of, and the roofs were constructed by laying over the rafters a boarding, upon which the unsaturated paper, the sides of which lapped over the other, was fastened with short tacks. The surface of the paper was next coated with heated pine tar to make it waterproof. The thin layer of tar was soon destroyed by the weather, so that the paper, swelled by the absorption of rain water, lost its cohesiveness and was soon destroyed by the elements. This imperfect method of roof covering found no great favor and was but seldom employed.

In Germany the architect Gilly was first to become interested in tar paper roofing, and recommended it in his architecture for the country. Nevertheless the new style of roof covering was but little employed, and was finally abandoned during the first year of the 19th century. It was revived again in 1840, when people began to take a renewed interest in tar paper roofs, the method of manufacturing an impermeable paper being already so far perfected that the squares of paper were dipped in tar until thoroughly saturated. The roof constructed of these waterproof paper sheets proved itself to be a durable covering, being unimpenetrable to atmospheric precipitations, and soon several factories commenced manufacturing the paper. The product was improved continually and its method of manufacture perfected. The good qualities of tar paper roofs being recognized by the public, they were gradually adopted. The costly pine tar was soon replaced by the cheaper coal tar. Square sheets of paper were made at first; they were dipped sufficiently long in ordinary heated coal tar, until perfectly saturated. The excess of tar was then permitted to drip off, and the sheets were dried in the air. The improvement of passing them through rollers to get rid of the surplus tar was reserved for a future time, when an enterprising manufacturer commenced to make endless tar paper in place of sheets. Special apparatus were constructed to impregnate these rolls with tar; they were imperfect at first, but gradually improved to a high degree. Much progress was also made in the construction of the roofs, and several methods of covering were devised. The defects caused by the old method of nailing the tar paper direct upon the roof boarding were corrected; the consequence of this method was that the paper was apt to tear, caused by the unequal expansion of the roofing boards and paper, and this soon led to the idea of making the latter independent of the former by nailing the sides of the paper upon strips running parallel with the gable. The use of endless tar paper proved to be an essential advantage, because the number of seams as well as places where it had to be nailed to the roof boarding was largely decreased. The manufacture of tar paper has remained at about the same stage and no essential improvements have been made up to the present. As partial improvement may be mentioned the preparation of tar, especially since the introduction of the tar distillery, and the manufacture of special roof lacquers, which have been used for coating in place of the coal tar. As an essential progress in the tar paper roofing may be mentioned the invention of the double tar paper roof, and the wood cement roof, which is regarded as an offshoot.

The tar paper industry has, within the last forty years, assumed great dimensions, and the preferences for this roofing are gaining ground daily. In view of the small weight of the covering material, the wood construction of the roof can be much lighter, and the building is therefore less strained by the weight of the roof than one with the other kind, so that the outer walls need not be as heavy. Considering the price, the paper roof is not only cheaper than other fireproof roofs, but its light weight makes it possible for the whole building to be constructed lighter and cheaper. The durability of the tar paper roof is satisfactory, if carefully made of good material; the double tar paper roof, the gravel double roof, and the wood cement roof are distinguished by their great durability.

These roofs may be used for all kinds of buildings, and not only are factories, storehouses, and country buildings covered with it, but also many dwellings. The most stylish residences and villas are at present being inclosed with the more durable kinds; the double roof, the gravel double roof, and the wood cement roof. For factory buildings, which are constantly shaken by the vibrations of the machinery, the tar paper roof is preferable to any other.

In order to ascertain to what degree tar paper roofs would resist fire, experiments were instituted at the instigation of some of the larger manufacturers of roofing paper, in the presence of experts, architects, and others, embracing the most severe tests, and it was fully proved that the tar paper roof is as fireproof as any other. These experiments were made in two different ways; first, the readiness of ignition of the tar paper roof by a spark or flame from the outside was considered, and, second, it was tested in how far it would resist a fire in the interior of the building. In the former case, it was ascertained that a bright, intense fire could be kept burning upon the roof for some time, without igniting the woodwork of the roof, but heat from above caused some of the more volatile constituents of the tar to be expelled, whereby small flames appeared upon the surface within the limits of the fire; the roofing paper was not completely destroyed. There always remained a cohesive substance, although it was charred and friable, which by reason of its bad conductivity of heat protected the roof boarding to such an extent that it was "browned" only by the developed tar vapors. A fire was next started within a building covered with a tar paper roof; the flame touched the roof boarding, which partly commenced to char and smoulder, but the bright burning of the wood was prevented by the air-tight condition of the roof; the fire gases could not escape from the building. The smoke collecting under the roof prevented the entrance of fresh air, in consequence of which the want of oxygen smothered the fire. The roofing paper remained unchanged. By making openings in the sides of the building so that the fire gases could escape, the wood part of the roof was consumed, but the roofing paper itself was only charred and did not burn. After removing the fire in contact with the paper, this ceased burning at once and evinced no disposition whatever to spread. In large conflagrations, also, the tar paper roofs behaved in identically a similar manner. Many instances have occurred where the tar paper roof prevented the fire from spreading inside the building, and developing with sufficient intensity to work injury.

As it is of interest to the roofer to know the manner of making the material he uses, we give in the following a short description of the manufacture of roofing paper. At first, when square sheets were used exclusively, the raw paper consisted of ordinary dipped or formed sheets. The materials used in its manufacture were common woolen rags and other material. In order to prepare the pulp from the rags it is necessary to cut them so small that the fabric is entirely dissolved and converted into short fibers. The rags are for this purpose first cut into pieces, which are again reduced by special machines. The rags are cut in a rag cutting machine, which was formerly constructed similar to a feed cutter; later on, more complicated machines of various constructions were employed. It is not our task to describe the various kinds, but we remain content with the general remark that they are all based on the principles of causing revolving knives to operate upon the rags. The careful cleansing of the cut rags, necessary for the manufacture of paper, is not required for roofing paper. It is sufficient to rinse away the sand and other solid extraneous matter. The further reduction of the cut rags was formerly performed in a stamp mill, which is no longer employed, the pulp mill or rag engine being universally used.

The construction of this engine may be described as follows: A box or trough of wood, iron, or stone is by a partition divided into two parts which are connected at their ends. At one side upon the bottom of the box lies an oakwood block, called the back fall. In a hollow of this back fall is sunk the so-called plate, furnished with a number of sharp steel cutters or knives, lying alongside of each other. A roller of solid oakwood, the circumference of which is also furnished with sharp steel cutters or knives, is fastened upon a shaft and revolves within the hollow. The journal bearings of the shaft are let into and fastened in movable wooden carriers. The carriers of the bearings may be raised and lowered by turning suitable thumb-screws, whereby the distance between the roller and the back fall is increased or decreased. The whole is above covered with a dome, the so-called case, to prevent the throwing out of the mass under the operation of grinding. The roller is revolved with a velocity of from 100 to 150 revolutions per minute, whereby the rags are sucked in between the roller and the back fall and cut and torn between the knives. At the beginning of the operation, the distance between the roller and the back fall is made as great as possible, the intention being less to cut the rags than to wash them thoroughly. The dirty water is then drawn off and replaced by clean, and the space of the grinding apparatus is lessened gradually, so as to cut the rags between the knives. The mass is constantly kept in motion and each piece of rag passes repeatedly between the knives. The case protects the mass from being thrown out by the centrifugal force. The work of beating the rags is ended in a few hours, and the ensuing thin paste is drawn off into the pulp chest, this being a square box lined with lead.

From the pulp chest it passes to the form of the paper machine. This form consists of an endless fine web of brass wire, which revolves around rollers. The upper part of this form rests upon a number of hollow copper rollers, whereby a level place is formed. The form revolves uniformly around the two end rollers, and has at the same time a vibratory motion, by which the pulp running upon the form is spread out uniformly and conducted along, more flowing on as the latter progresses. The water escapes rapidly through the close wire web. In order to limit the form on the sides two endless leather straps revolve around the rollers on each side, which touch with their lower parts the form on both sides and confine the fluid within a proper breadth. The thickness of the pulp is regulated at the head of the form by a brass rule standing at a certain height; its function is to level the pulp and distribute it at a certain thickness. The continually moving pulp layer assumes greater consistency the nearer it approaches to the dandy roll. This is a cylinder covered with brass wire, and is for the purpose of compressing the paper, after it has left the form, and free it from a great part of the water, which escapes into a box. The paper is now freed of a good deal of the fluid, and assumes a consistency with which it is enabled to leave the form, which now commences to return underneath the paper, passing on to an endless felt, which revolves around rollers and delivers it to two iron rolls. The paper passes through a second pair of iron rollers, the interiors of which are heated by steam. These rollers cause the last of the water to be evaporated, so that it can then be rolled upon reels. A special arrangement shaves the edges to the exact size required.

The paper is made in different thicknesses and designated by numbers to the size and weight.

Waste paper, bookbinders' shavings, etc., can be used for making the paper. As much wool as possible should be employed, because the wool fiber has a greater resistance than vegetable fiber to the effects of the temperature. By wool fiber is understood the horny substance resembling hair, with the difference that the former has no marrowy tissue. The covering pellicle of the wool fiber consists of flat, mostly elongated leaves, with more or less corners, lying over each other like scales, which makes the surface of the fiber rough; this condition, together with the inclination of curling, renders it capable of felting readily. Pure wool consists of a horny substance, containing both nitrogen and sulphur, and dissolves in a potash solution. In a clean condition, the wool contains from 0·3 to 0·5 per cent. of ash. It is very hygroscopical, and under ordinary circumstances it contains from 13 to 16 per cent. humidity, in dry air from 7 to 11 per cent., which can be entirely expelled at a temperature of from 226 to 230 degrees Fahrenheit. Wool when ignited does not burn with a bright flame, as vegetable fiber does, but consumes with a feeble smouldering glow, soon extinguishes, spreading a disagreeable pungent vapor, as of burning horn. By placing a test tube with a solution of five parts caustic potash in 100 parts water, a mixture of vegetable fibers and wool fibers, the latter dissolve if the fluid is brought to boiling above an alcohol flame, while the cotton and linen fibers remain intact.

The solubility of the woolen fibers in potash lye is a ready means of ascertaining the percentage of wool fiber in the paper. An exhaustive analysis of the latter can be performed in the following manner: A known quantity of the paper is slowly dried in a drying apparatus at temperature of 230° Fahrenheit, until a sample weighed on a scale remains constant. The loss of weight indicates the degree of humidity. To determine the ash percentage, the sample is placed in a platinum crucible, and held over a lamp until all the organic matter is burned out and the ash has assumed a light color. The cold ash is then moistened with a carbonate of ammonia solution, and the crucible again exposed until it is dark red; the weight of the ash is then taken. To determine the percentage of wool, a sample of the paper is dried at 230° Fahrenheit and weighed, boiled in a porcelain dish in potash lye 12° B. strong, and frequently stirred with a glass rod. The wool fiber soon dissolves in the potash lye, while the vegetable fiber remains unaltered. The pulpy mass resulting is placed upon a filter, dried at 212° Fahrenheit, and after the potash lye has dripped off, the residue, consisting of vegetable fiber and earthy ash ingredients, is washed until the water ceases to dissolve anything. The residue dried at 212° Fahrenheit is weighed with a filter, after which that of the latter is deducted. The loss of weight experienced is essentially equal to the loss of the wool fiber. If the filtrate is saturated with hydrochloric acid, the dissolved wool fiber separates again, and after having been collected upon a weighed filter, it may be weighed and the quantity ascertained.

The weight of the mineral substances in the raw paper is ascertained by analyzing the ash in a manner similar to that above described. The several constituents of the ash and the mineral added to the raw paper are ascertained as follows: Sufficient of the paper is calcined in the manner described; a known quantity of the ash is weighed and thrown into a small porcelain dish containing a little distilled water and an excess of chemically pure hydrochloric acid. In this solution are dissolved the carbonates, carbonate of lime, carbonate of magnesia, a little of sulphate of alumina, as well as metallic oxides, while silicate of magnesia, silicic acid, sulphate of lime (gypsum) remain undissolved. The substance is heated until the water and excess of free hydrochloric acid have been driven off; it is then moistened with a little hydrochloric acid, diluted with distilled water and heated. The undissolved residue is by filtering separated from the dissolved, the filter washed with distilled water, and the wash water added to the filtrate. The undissolved residue is dried, and after the filter has also been burned in due manner and the ash added, the weight is ascertained. It consists of clay, sand, silicic acid and gypsum.

The filtrate is then poured into a cylinder capable of holding 100 cubic centimeters, and furnished with a scale; sufficient distilled water is then added until the well-shaken fluid measures precisely 100 cubic centimeters. By means of this measuring instrument, the filtrate is then divided into two equal portions. One of these parts is in a beaker glass over-saturated with chemically pure chloride of ammonia, whereby any iron of oxide present and a little dissolved alumina fall down as deposit. The precipitate is separated by filtering, washed, dried at 212° Fahrenheit and weighed. To the filtrate is then added a solution of oxalate of ammonia until a white precipitate of oxalate of lime is formed. This precipitate is separated by filtering, washed, dried and when separated from the filter, is collected upon dark satinized paper; the filter itself is burned and the ash added to the oxalate of lime. This oxalate of lime is then heated to a dark red heat in a platinum crucible with lid until the oxalate of lime is converted into acarbonate of lime. By the addition of a few drops of carbonate of ammonia solution and another slight heating of the crucible, also the caustic lime produced in the filter ash by heating, is reconverted into carbonate of lime, and after cooling in the exsiccator,

the whole contents of the crucible is weighed as carbonate of lime, after deducting the known quantity of filter ash.

Any magnesia present in the filtrate of the oxalate of limeis by the addition of a solution of phosphate of soda separated as phosphate of ammonia and magnesia, after having stood twenty-four hours. The precipitate is filtered off, washed with water to which a little chloride of ammonia is added, dried, and after calcining the fiber and adding the filter ash, glow heated in the crucible. The glowed substance is weighed after cooling, and is pyrophosphate of magnesia, from which the magnesia or carbonate of magnesia is calculated stoichiometrically. All the ascertained sums must be multiplied by 2, if they are to correspond to the analyzed and weighed quantity of ash.

The second half of the filtrate is used for determining the small quantity of sulphate of lime still contained in the hydrochlorate solution. By adding chloride of barium solution the sulphuric acid is bound to the barytes and sulphate of baryta separates as white precipitate. This is separated by filtering, washed, dried and weighed in the customary manner. From the weight of the sulphate of baryta is then computed the weight of sulphate of lime, which has passed over into solution. The ascertained sum is also to be multiplied with 2.

The manufacture of roll tar paper from the roll paper was at first found to be difficult, as it was impossible to submerge a surface larger than from ten to fifteen square yards, rolled up, in the tar, because more would have required too large a pan. Besides this, the paper tears easily, when it is in the hot tar. All kinds of experiments were tried, in order to impregnate the surface of the paper without employing too large a pan.

The following method was tried at first: The roll paper was cut into lengths of ten yards, which were rolled up loosely, so that a certain space was left between the different coils. These loose rolls, of course, occupied much space and could be put into the tar only in a standing position, because in a horizontal one the several coils would have pressed together again. The loose roll was therefore slipped over a vertical iron rod fastened into a circular perforated wooden foot. The upper end of this iron rod ended in a ring, in which the hook of a chain or rope could be fastened. With the aid of a windlass the roll was raised or lowered. When placed in the pan with boiling tar, it was left there until thoroughly saturated. It was then taken out, placed upon a table, and the excess of tar allowed to drip off into a vessel underneath. After partially drying, the roll was spread out in open air, occasionally turned, until sufficiently dried, when it was rolled up again.

In order to neutralize the smeary, sticky condition of the surface and avoid the disagreeable drying in open air, the experiment of strewing sand on the sticky places was tried next. The weight of the paper was largely increased by the sand, and appeared considerably thicker. For this reason the method of sanding the paper was at once universally adopted. To dispense with the process of permitting the surplus tar to drip off, means were devised by which it was taken off by scrapers, or by pressing through rollers. The scrapers, two sharp edged rods fastened across the pan, were then so placed that the paper was drawn through them. The excess of tar adhering to its surface was thereby scraped off and ran back into the pan.

This work, however, was performed better and to more satisfaction by a pair of rollers fastened to the pan. These performed a double duty; thoroughly removed the tar from the surface and by reason of their pressure they caused a more perfect incorporation of the tar with the fibers of the paper. Finally, different factories employed different methods of manufacture, one of which was to cut the rolls into definite lengths of about ten yards; these were then rerolled very loosely and immersed in the hot tar until sufficiently saturated. The paper was then passed through the roller, much pressure exerted, and then loosely rolled up again. Being tarred once, it was then laid into a second pan with hot tar, reeled out after a time, strewn with sand, and rolled up again. Another method was to cut clothes lines into lengths of about fifteen yards, and at a distance of two inches have knots tied in them. The paper was cut in lengths of ten or fifteen yards, three pieces of the knotted clothes line were then rolled between the loose coils of paper, which was then submerged in the tar, which on account of the knots could penetrate the paper. The paper was next sanded by permitting its lower surface to pass over dry sand in a box standing on the floor. A workman rolled off the paper, and with his hand he strews sand on the upper surface. The rolling taking place on the edge of a table, by means of a crank, the excess of sand dropped off.

It is said by this method two workmen, one of which tends to the rolling and sanding, the other turning the crank, could turn out eighty rolls per day. This method is still in use. It is useless to describe the many antiquated methods in vogue in smaller factories, and it can truthfully be said that nearly all of them are out of date. It appears to be the fact of almost all inventions that when reduced to practical use, the arrangements, apparatus, and working methods employed are generally of the most complicated nature, and time and experience only will simplify them. This has been also the case with the methods in the roofing paper industry, which are at present gradually being reduced to a practical basis. The method gradually adopted has been described in the preceding. The pan is of a certain length, whereby it becomes possible to saturate the paper by slowly drawing it through the heated tar. This is the chief feature. The work is much simplified thereby and the workmen need not dip their hands into the tar or soil them with it. The work of impregnating has become much cleaner and easier, while at the same time the tar can be heated to a much higher temperature. The pan is generally filled with distilled coal tar, and the heating is regulated in such a manner that the temperature of the impregnating mass is raised far beyond 212° Fahrenheit. This accelerates the penetration, which takes place more quickly as the degree of heat is raised, which may be almost up to the boiling point of the tar, as at this degree the paper is not destroyed by the heat. In order to prevent the evaporation of the volatile ingredients of the tar, the pan is covered with a sheet iron cover, with a slot at the place where the paper enters into the impregnating mass and another at the place where it issues. The tar is always kept at the same level, by occasional additions.

The roll of paper is mounted upon a shaft at the back end of the pan, and by suitable arrangement of guide rollers it unwinds slowly, passes into the tar in which it is kept submerged. The guide rollers can be raised so that when a new roller is set up they can be raised out of the tar. The end of the paper is then slipped underneath them above the surface of the tar, when having passed through the squeezing rollers, it is fastened to the beaming roller, and the guide rollers are submerged again. A workman slowly turns the crank of the beaming roller.

This motion draws the paper slowly through the fluid, the roll at the back end unwinding. The speed with which the squeezing rollers are turned is regulated in such a manner that the paper remains sufficiently long underneath the fluid to be thoroughly impregnated with it. The workmen quickly learn by experience how fast to turn the crank. The hotter the tar, the more rapid the saturation; the high degree of heat expels the air and evaporates the hygroscopic fluid in the pores of the paper. The strong heating of the tar causes another advantage connected with this method. The surface of the paper as it issues from the squeezing rollers is still very hot, and a part of the volatile oils evaporate very quickly at this high temperature. The surface is thereby at once dried to a certain degree and at the same time receives a handsome luster, as if it had been coated with a black lacquer. The paper is sanded in a very simple manner without the use of mechanical apparatus; as it is being wrapped into a coil, it passes with its lower surface over a layer of sand, while the workman who tends to rolling up strews the inside with sand. The lower surface is coated very equally. Care only being necessary that the sand lies smooth and even at all times. When the workman has rolled up ten or fifteen yards, he cuts it across with a knife and straightedge, so that the paper is cut at right angles with its sides.

There are three different sorts of roofing paper, according to the impregnating fluid used in its manufacture. The ordinary tar paper is that saturated with clear cold tar. This contains the greatest amount of fluid ingredients and is very raggy in a fresh condition. It is easy to see that the volatile hydrocarbons evaporate in a short time, and when expelled, the paper becomes stiffer and apparently drier. This drying, or the volatilization of the hydrocarbons, causes pores between the fibers of the paper. These pores are highly injurious to it, as they facilitate a process of decomposition which will ruin it in a short time.

Roofing paper can be called good only when it is essentially made from woolen rags, and contains either very few or no earthy additions. It is beyond doubt that the durability of a roofing paper increases with the quality of wool fiber it contains—vegetable fibers and earthy additions cause a direct injury. Reprehensible altogether is any combination with lime, either in form of a carbonate or sulphate, because the lime enters into chemical combination with the decomposition products of the tar.

The general nature of gravel is too well known to require description. The grains of quartz sand are either sharp cornered or else rounded pieces of stone of quartz, occasionally mixed with grains of other amorphous pieces of silica—such as horn stone, silicious slate, carnelian, etc.; again, with lustrous pieces of mica, or red and white pieces of feldspar. The gravel used for a tar paper roof must be of a special nature and be prepared for the purpose. The size of its grains must not exceed a certain standard—say, the size of a pea. When found in the gravel bank, it is frequently mixed with clay, etc., and it cannot be used in this condition for a roof, but must be washed. The utensils necessary for this purpose are of so simple and suggestive a nature that they need not be described. Slag is being successfully used in place of the gravel. It is easily reduced to suitable size, by letting the red hot mass, as it runs from the furnace, run into a vessel with water. The sudden chilling of the slag causes it to burst into fragments of a sharp cornered structure. It is next passed through a sieve, and the suitably sized gravel makes an excellent material, as it gives a clean appearance to the roof.

The thinking mind can easily go one step further and imagine that, since the tar contains a number of volatile hydrocarbons, it might be made more adaptable for impregnation by paper by distilling it, as by this process the fluid would lose its tendency to evaporate and the percentage of resinous substances increase. Singular to say, there was a prejudice against the employment of distilled tar, entertained by builders and people who had no knowledge of chemistry. Increasing intelligence and altered business circumstances, however, brought about the almost universal employment of distilled tar, and every large factory uses it at present. The roofing paper prepared with distilled tar is perhaps most suitably called asphaltum paper, as this has been used in its manufacture. It possesses properties superior to the ordinary tar paper, one of which is that immediately after its manufacture, as soon as cold, it is dry and ready for shipment; nor does it require to be kept in store for a length of time, and it has also a good, firm body, being as flexible and tough as leather. It is very durable upon the roof, and remains flexible for a long time. It is true that asphaltum papers will always in a fresh state contain a small percentage of volatile ingredients, which after a while make it hard and friable upon the roof; but, by reason of its greater percentage of resinous components, it will always preserve a superior degree of durability and become far less porous. One hundred parts by weight absorb 140 or 150 parts by weight of coal tar. A factory which distilled a good standard tar for roofing paper recovered, besides benzole and naphtha, also about ten per cent. of creosote oil, used for one hundred parts raw paper, 176·4 partially distilled tar. Experiments on a larger as well as a smaller scale reduced this quantity to an average of 141·5 parts for one hundred parts raw paper. The weight of sanded paper is very variable, as it depends altogether upon the size of the sand grains. It may be stated generally that the weight of the sand is as large as that of the tarred paper.

The kinds of roofing paper saturated with other additions besides coal tar form a separate class, in order to neutralize the defects inherent in coal tar. These additions were originally for the purpose of thickening the paper and making it stiffer and drier. The most ordinary and cheapest thickener was the coal pitch. Although the resinous substances are increased thereby, still the light tar oils remain to evaporate, and the paper prepared with such a substance readily becomes hard and brittle. A better addition is the natural asphaltum, because it resists better the destroying influence of the decomposition process, and also, to a certain degree, protects the coal tar in which it is dissolved. The addition of natural ashphaltum doubtless caused the name of "asphaltum roofing paper." Resin, sulphur, wood tar and other substances were also used as additions; each manufacturer kept his method secret, however, and simply pointed out by high sounding title in what manner his paper was composed. In most cases, however, this appellation was applied to the ordinary tar paper; the impregnating substance was mixed only with coal pitch, or else a roofing paper saturated with distilled tar. The costly additions, by the use of which a high grade of roofing paper can doubtless be produced, largely increased its price, and on account of the constant fall of prices of the article, its use became rather one of those things "more honored in the breach than in the observance," and was dispensed with whenever practicable. The crude paper is the foundation of the roofing paper. The qualities of a good, unadulterated paper have already been stated. At times, the crude paper contains too many earthy ingredients which impair the cohesion of the felted fibrous substance, and which especially the carbonate of lime is very injurious, as it readily effects the decomposition of the coal tar. The percentage of wool, upon which the durability of the paper depends very largely, is very small in some of the paper found in the market. In place of woolen rags, cheap substitutes have been used, such as waste, which contains vegetable fibers. Since this cannot resist the decomposition process for any length of time, it is evident that the roofing paper which contains a noticeable quantity of vegetable fibers cannot be very durable. To judge from the endeavors made to improve the coal tar, it may be concluded that this material does not fully comply with its function of making the roofing paper perfectly and durably waterproof. The coal tar, be it either crude or distilled, is not a perfect impregnating material, and the roofing paper, saturated with it, possesses several defects. Let us in the following try to ascertain their shortcomings, and then express our idea in what manner the roofing paper may be improved. It was previously mentioned that every tar roofing paper will, after a greater or smaller lapse of time, assume a dry, porous, friable condition, caused by the volatilization of a part of the constituents of the tar. This alteration is materially assisted by the oxygen of the air, which causes the latter to become resinous and exerts a chemical influence upon them. By the volatilization of the lighter tar oils, pores are generated between the fibers of the roofing paper, into which the air and humidity penetrate. In consequence of the greatly enlarged surface, not only the solid ingredients of the tar, which still remain unaltered, are exposed to the action of the oxygen, but also the fibers of the roofing paper are exposed to decomposition. How destructive the alternating influence of the oxygen and the atmospheric precipitations are for the roofing paper will be shown by the following results of tests. It will have been observed that the rain water running from an old paper roof, especially after dry weather, has a yellowish, sometimes a brown yellow color. The supposition that this colored rain water might contain decomposition products of the roofing paper readily prompted itself, and it has been collected and analyzed at different seasons of the year. After a period of several weeks of fair weather during the summer, rain fell, and the sample of water running from a roof was caught and evaporated; the residue when dried weighed 1·68 grammes. It was of a brownish black color, fusible in heat and readily soluble, with a yellow brown color in water. The dark brown substance readily dissolved in ammonia, alcohol, dilute acid, hydrochloric acid, sulphuric acid, and decomposed in nitric acid, but did not dissolve in benzine or fat oil. After several days' rain during the summer, a quantity of the water was caught, evaporated, and the residue dried. Its characteristics were similar to those above mentioned. By an experiment instituted in water under conditions similar to the first mentioned, the dry brown substance weighed 71 grammes. It possessed the same characteristics. In the solution effected with water containing some aqua ammonia of the brown substance, a white precipitate of oxalate of lime occurred when an oxalate of ammonia solution was added, but the brown substance remained in solution. A further precipitation of oxalate of lime was produced by a solution of oxalic acid, but the brown organic substance remained in solution. This organic substance being liberated from the lime was evaporated, and left a dry, resinous, fusible brownish black substance, which also dissolved readily in water. It will be seen from these trials that the substance obtained from the rain water running from a paper roof is a combination of an organic acid with lime, which readily dissolves in water, and that also the free organic acid combined with the lime dissolves easily in water.

The question concerning the origin of this organic substance or its combination with lime can only be answered in one way, viz., that it must have been washed by the rain water out of the paper. But since such a solid substance, easily soluble in water, is contained neither in the fresh roofing paper nor in the coal tar, the only deduction is that it must have arisen by the decomposition of the tar, in consequence of the operation of the oxygen. The lime comes from the coating substance of the roof, for which tar mixed with coal pitch was used. The latter was fused with carbonate of lime. These analyses furthermore show that the formation of the organic acid easily soluble in water depends upon the season; and that a larger quantity of it is generated in warm, sunny weather than in cold, without sunshine. This peculiarity of the solid, resinous constituents of the coal tar, to be by the operation of the atmospheric oxygen altered into such products that are readily soluble in water, makes the tar very unsuitable as a saturative substance for a roofing paper. How rapidly a paper roof can be ruined by the generation of this injurious organic acid will be seen from the following calculation: Let us

suppose that an average of 132 gallons of rain water falls upon ten square feet roof surface per year, and that the arithmetical mean 0·932 of the largest (1·680) and smallest number (0·184) be the quantity of the soluble brown substance which on an average is dissolved in one quart of rain water; hence from ten square feet of roof surface are rinsed away with the rain water per year 466 grammes of the soluble decomposition products of the tar. The oxidation process will not always occur as intensely as by a paper roof, ten years old and painted two years ago, which instigated above described experiment. As long as the roofing paper is fresh and less porous, especially if the occurring pores are filled and closed again by repeated coatings, oxidation will take place far less rapidly. Besides this, the protective coating applied to the roof surface is exposed most to this oxidation process. Even by assuming this constantly progressive destructive action of the oxygen on the roofing paper to be much less than above stated, we can readily imagine that it must be quite large. If it is desired to produce a material free of faults, it is first of all indispensable that unobjectionable raw material be procured. Coal tar was formerly used almost exclusively for the coating of a roof. It was heated and applied hot upon the surface. In order to avoid the running off of the thinly fluid mass, the freshly coated surface was strewn with sand. The most volatile portion of the tar evaporated soon, whereby the coating became thicker and finally dried. The bad properties of the coal tar, pointed out elsewhere, madeit very unsuitable even for this purpose, and experiments were instituted to compound mixtures, by adding other ingredients to the tar, that should more fully comply with its function. It may be said in general that the coating masses for roofs can be divided into two classes: either as lacquers or as cements. To the former may be classed those of a fairly thinly fluid consistency, and which contain volatile oils in such quantities that they will dry quickly. Cements are those of a thickly fluid consistency, and are rendered thus fluid by heating. It is not necessary that the coating applied should harden quickly, as it assumes soon after its application a firmness sufficient to prevent it from running off the roof. Coal tar is to be classed among lacquers. If it has been liberated by distillation from the volatile oils, it is made better suited for the purpose than the ordinary kind. The mass contains much more asphaltum, and after drying, which takes place soon, it leaves a far thicker layer upon the roof surface, while the pores, which had formed in the roofing paper consequent on drying, are better filled up. Nevertheless, the distilled tar also has retained the property of drying with time into a hard, vitreous mass, and ultimately to be destroyed by decomposition.—*The Roofer.*

A PHYSICAL LABORATORY INDICATOR.

THE difficulties attending the management of a physical laboratory are much greater than those of a chemical one. The cause of this lies in the fact that in the latter the apparatus is less complicated and the pieces less varied. Any contrivance that will reduce the labor and worry connected with the running of a laboratory is valuable.

A physical laboratory may be arranged in several ways. The apparatus may be kept in a store room and such as is needed may be given to the student each day and removed after the experiments are performed; or the apparatus for each experiment or system of experiments may be kept in a fixed place in the laboratory ready for assembling; for certain experiments the apparatus may be kept in a fixed place in the laboratory and permanently arranged for service.

Each student may have his own desk and apparatus or he may be required to pass from desk to desk. The latter method is preferable.

When a store room is used the services of a man are required to distribute and afterward to collect. If the apparatus is permanently distributed, a large room is necessary, but the labor of collecting and distributing is done away with.

There are certain general experiments intended to show the use of measuring instruments which all students must perform. To illustrate the use of the indicator I have selected an elementary class, although the instrument is equally applicable to all classes of experiments.

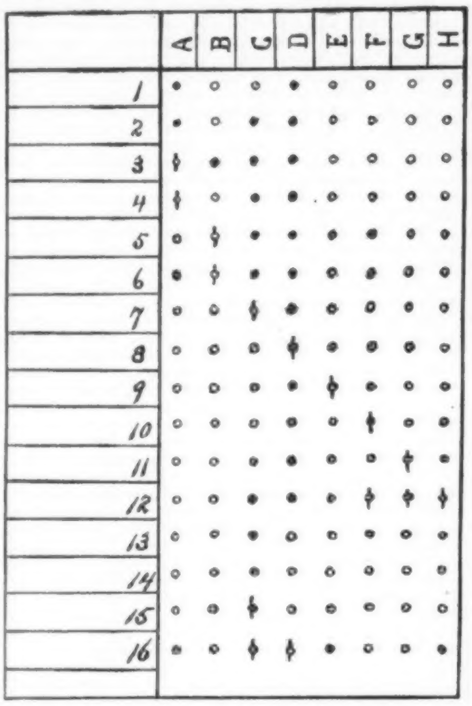
Having selected a suitable room, tables may be placed against the walls between the windows and at other convenient places. Shallow closets are built upon these tables against the wall; they have glass doors and are fitted with shelves properly spaced. A large number of light wooden boxes are prepared, numbered from one up to the limit of the storage capacity of the closets. A number corresponding to that upon the box is placed upon the shelf, so that each one after removal may be returned to its proper place without difficulty. On the front of the box is a label upon which is written the experiment to be performed or the name of the apparatus whose use is to be learned, references to various books, which may be found in the laboratory library, and the apparatus necessary for the experiment, which ought to be found in the box. If any parts of the apparatus are too large to be placed in the box, the label indicates by a number where it may be found in the storage case.

It is evident that, instead of the above arrangement, all the boxes can be stacked in piles in a general store room. The described arrangement is preferable, as it prevents confusion in collecting and distributing apparatus when the class is large.

The Indicator (see figure).—Some device is evidently desirable to direct the work of a laboratory with the least trouble and friction possible. I have found that the old fashioned "peg board," formerly used in schools to record the demerits of scholars, modified as in the following description, leaves nothing to be desired.

The requirements of such an instrument are these: It must show the names of the members of the class; it must contain a full list of the experiments to be performed; it must refer the student to the book and page where information in reference to the experiments or apparatus may be found; it must show what experiments are to be performed by each student at a given time; it must give information as to the place in the laboratory where the apparatus is deposited; it must show to the instructor what experiments have been performed by each student; it must prevent the assignment of the same experiment to two students; it must enable the instructor to assign the same experiment to two or more students; it must form a complete record of what has been done, what work is incomplete, and what experiments have not yet been assigned; it must also be so arranged that new experiments or sets of experiments may be exhibited.

The indicator consists of a plank of any convenient length and breadth. The front surface is divided into squares of such size that the pegs may be introduced and withdrawn with ease. At each corner of the squares holes are bored into which nails may be placed. There is a blank border at the top and another on the left side. At the top of each vertical column of holes is placed a card holder. This is made of light tin turned up on the long edges—which are



A, B, C, etc., are cards upon which are the names of students. 1, 2, 3, etc., are cards like the one described in the article. The small circles represent unassigned experiments. The black circles (slate nails) represent work done. The caudate circles (brass nails) represent work assigned.

vertical—and tacked to the board. Opposite each horizontal row of holes is a similar tin card holder, but of greater length, and having its length horizontal. The holders at the top of the board contain cards upon which the names of the class are written.

Cards, like the following, are prepared for the horizontal holders.

Stewart & Gee 229 Physical Manip. 85 Glazebrook & Shaw 132	Intensity of Gravity—Borda's Method	39

These cards are numbered from one to any desired number and are arranged in the holders consecutively.

Two kinds of nails are provided to fit the holes in the board: An ordinary slate nail and a common picture frame nail with a brass head. The latter indicates work to be done, the former work done.

To prepare the board for service, brass headed nails are placed opposite each experiment, and below the names, care being taken not to have more than one nail in the same horizontal row, unless it is intended that two persons or more are to work upon the same experiment.

There will be no conflict when the brass nails occupy diagonal lines. If they do not, a glance will show the fact.

After an experiment has been performed and a report made upon the usual blank, the brass nail is removed and a slate nail put in its place.

The board will show by the slate nails what work has been done by each student, by the brass nails what is yet to be done, and by the empty holes, experiments which have been omitted or are yet to be assigned. A slate nail opposite an experiment card indicates that that experiment may now be assigned to another person.

It is evident that the schedule for a whole term may be arranged in a few minutes and that the daily changes require very little time.

The board is hung in a convenient place. The student as he enters the laboratory looks for his name on the upper cards and under it for the first brass nail in the vertical column: to the left he finds the experiment card. On the left hand end of the slip he sees the book references, on the right hand end a number—39 in the sample card given above. Knowing the number, he proceeds to a desk and finds a box numbered in the same manner. He removes the box from the closet. On the label of the box is a list of all the apparatus necessary, which he will find in the box; the label also contains the book references. He performs the experiment, fills up a blank which he gives to the instructor, puts all the materials back in the box, replaces the box in its proper place in the closet and proceeds with the next experiment. With this indicator there is no difficulty in managing fifty students or more.

Comparatively little apparatus need be duplicated. Where apparatus is fixed against a wall a number may be tacked upon the wall and a card containing the information desired. The procedure is then the same as with the boxes. The cards on the board being removable, other ones may be inserted containing information in reference to other boxes having the same number but containing different materials.

There can be no successful tampering with the board, for the record of experiments performed is upon the blanks which the students turn in and also in the individual note books which are written up and given to the instructor for daily examination.

Lafayette College. J. W. MOORE.

NEW METHOD OF EXTINGUISHING FIRES

THIS is by George Dickson, of Toronto, Canada, and David Alanson Jones.

A mixture of water and liquefied carbon dioxide upon being discharged through pipes at high pressure causes the rapid expansion of the gas and converts the mixture into spray more or less frozen, and portions of the liquid carbon dioxide are frozen, owing to its rapid expansion, and are thus thrown upon the fire in a solid state, where said frozen carbon dioxide in its further expansion not only acts to put out the fire, but cools the surface upon which it falls, and thus tends to prevent reignition.

A represents a receptacle sufficiently strong to stand a pressure of not less than a thousand pounds to the square inch.

B B water receptacles.

In the drawings we have shown two receptacles B and only one receptacle A; but we do not wish to confine ourselves to any particular number, nor do we

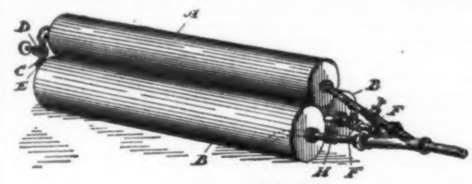


Fig. 1

wish to confine ourselves to the horizontal position in which the receptacles are shown.

C is a pipe leading from the receptacle A to a point at or near the bottom of the receptacle B.

F is a pipe through which the mixture of water and liquefied gas from the receptacle B is forced by the expansion of said liquefied gas, the said pipe taking the mixture of water and liquefied gas from the bottom of the receptacle.

To use the apparatus, open the stop cock D in the pipe C, leading to one of the receptacles B, whereupon, owing to the lower pressure in the cylinder B, the liquid carbon dioxide expands and rises to the top of the cylinder A and forces the liquid carbon dioxide into the cylinder B, the same as the superior steam of a boiler forces the water of the boiler out when the same is tapped below the surface of the liquid. Now upon opening the tap H, this superior gas forces out the mixture of water and liquid carbon dioxide, which suddenly expanding causes portions of the globules of

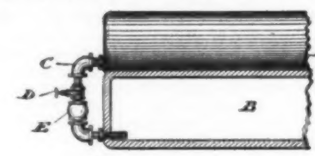


Fig. 2

liquefied gas to be frozen, and these, being protected by a rapidly evaporating portion of the liquefied gas, are thrown on the fire in solid particles. At the same time the water is blown into a spray, which is more or less frozen. The fire is thus rapidly extinguished by the vaporization of the carbon dioxide and water spray.

SMOKELESS GUNPOWDER.

By HUDSON MAXIM.

DURING the last forty years leading chemists have continued to experiment with a view to the production of a gunpowder which should be smokeless. But not until the last few years has any considerable degree of success been attained.

To be smokeless, a gunpowder must yield only gaseous products of combustion. None of the so-called smokeless powders are entirely smokeless, although some of them are very nearly so.

The smoke of common black gunpowder is largely due to minute particles of solid matter which float in the air. About one-half of the total products of combustion of black gunpowder of ordinary composition consists of potassium carbonate in a finely divided condition and of potassium sulphate, which is produced chiefly by the burning in the air of potassium sulphide, another production of combustion, as on the outrushing gases it is borne into the air in a fine state of division.

Another cause for the smoke of gunpowder is the formation of small liquid vesicles which condense from some of the products of combustion thrown into the air in a state of vapor, in the same manner as vesicles of aqueous vapor form in the air on the escape of highly heated steam from the whistle of a locomotive.

Broadly speaking, an explosive compound is one which contains, within itself, all the elements necessary for its complete combustion, and whose heated gaseous products occupy vastly more space than the original compound. Such compound usually consists of oxygen, associated with other elements, for which it has great affinity, and from which it is held from more intimate union, or direct chemical combination, under normal conditions, by being in combination as well with other elements for which it has less affinity, but which it readily gives up for the stronger affinities when explosion takes place, the other elements either combining with one another to form new compounds or being set free in an uncombined state.

An explosive is said to detonate when the above changes take place instantaneously, the action being transmitted with the speed of electricity by a sort of molecular rhythm from molecule to molecule throughout the entire substance of the compound.

An explosive is said to explode when the above

changes do not occur instantaneously throughout the whole substance, but whose combustion takes place from the surface inward of the particles or grains of which it is composed, thus requiring some definite lapse of time.

The elements of an explosive compound may be associated chemically as in nitro-glycerine and gun-cotton, which are chemical compounds, being the results of definite reactions. Or, an explosive may be a mere mechanical mixture of different substances comprising the necessary elements, as is ordinary black gunpowder, which is a compound of charcoal, sulphur and saltpeter, the saltpeter supplying the necessary oxygen.

No gunpowder can be smokeless in which saltpeter or any oxygen-bearing salt having a metallic base is employed, for when the salt gives up its oxygen, the base combines with other elements to produce a sulphate, a carbonate, or other salt, which, being solid, produces smoke. Therefore, to be smokeless, a gunpowder must contain no other elements than oxygen, hydrogen, nitrogen, and carbon, and in such proportions that the products of combustion shall be wholly gaseous. The nitric ethers—gun-cotton and nitro-glycerine—constitute such explosive compounds. These substances were formerly thought to be nitro-substitution compounds, but are now known to belong to the compound ethers of nitric acid.

Gun-cotton, discovered by Schonbein, in 1845, has since been looked upon as the most promising material for a smokeless gunpowder, it being a very powerful explosive and burning with practically no smoke. To-day, gun-cotton, in some form or other, constitutes the base of substantially all of the smokeless powders with which have been attained any considerable degree of success.

Gun-cotton alone and in its fibrous state has been found to be too quick, or violent, for propulsive purposes, such as use in firearms; as under such conditions of confinement it is very likely to detonate and burst the gun. However, if gun-cotton be dissolved in a suitable solvent, which is capable of being evaporated out, such as acetone, or acetate of ethyl, which are very volatile, it becomes, when thus dissolved and dried, a very hard, horn-like, amorphous substance, which may be used for a smokeless gunpowder. But this substance taken alone is very difficult to mould or granulate, and the loss of expensive solvents must necessarily be quite considerable.

When gun-cotton is reduced to a collodial solid, as above, and used as a smokeless gunpowder, the grains must be made comparatively small to insure prompt and certain ignition, and consequently the pressures developed in the gun are apt to be too great when charges sufficiently large are used to give desired velocities.

If, however, a compound be made of gun-cotton and nitro-glycerine, in about equal parts, by means of a volatile solvent or combining agent, such as one of the before mentioned, and the solvent evaporated out, we obtain practically a new substance and one which, as regards its explosive nature, is quite unlike either of its two constituents taken alone. The nitro-glycerine, furthermore, being itself a solvent of gun-cotton, much less of the volatile ether is necessary to render the compound of an amorphous character. Being quite plastic this substance may be wrought or moulded into any desired size or form of grain.

This simple compound of nitro-glycerine and gun-cotton, or with some slight modifications, has been found, when properly granulated, to be the most smokeless powder that has yet been discovered or invented. If pure chemicals are employed in the manufacture, and the gun-cotton and nitro-glycerine be made of the highest nitration and best quality, we have a smokeless powder which will possess the following desirable qualities:

1st. It is absolutely smokeless, that is, its products of combustion are entirely gaseous.

2d. Its products of combustion are in no way deleterious or unpleasant.

3d. It is perfectly safe to manufacture, handle and transport. There is no more danger of its exploding accidentally than there would be of an explosion of shavings or sawdust; for, unless well confined and set off with a strong primer, it will not explode at all. In the open its combustion is so slow as to in no way resemble or partake of the nature of an explosion.

4th. It is perfectly stable, and will keep any length of time absolutely without undergoing any change whatever, under all conditions of temperature or exposure to which gunpowder would ever be subjected.

5th. It is not hygroscopic, and may be soaked in water without being at all affected by it.

6th. It will not corrode the cartridge case.

7th. It will not foul the gun.

8th. It is sure of ignition with a good primer, and may be made to burn as slowly as desired by varying the character and size of the grains. Indeed, it may be made to burn so slowly as to fail of complete combustion before the bullet leaves the gun, and after firing several rounds, partly burned pieces of the powder may be picked up in front of the gun.

9th. In a shoulder arm, a velocity of 2,000 feet per second may be imparted to the bullet with this powder, and with a pressure in the chamber of the gun of not more than fifteen English tons. This is, of course, when the gun, cartridge case, primer, and projectile are adapted to the use of smokeless powder, and the granulation of the powder is adapted to them.

If what I have here claimed for the above smokeless powder be true, it would appear that it may be taken as really an ideal smokeless powder. Why, then, has it not already been universally adopted? Surely such a powder is just what every government is seeking. In reply to this, let me say that, in order for the above compound to be an effective and successful smokeless powder, with the manifestation of the many desirable qualities which I have recited, a great many other conditions are necessary, some of which I will mention. To arrive at the knowledge that this compound would constitute the best smokeless powder has required a great deal of experimenting. It was first thought that gun-cotton colloid, without any nitro-glycerine, that is, gun-cotton dissolved and dried, would burn more slowly, keep better, and give better ballistics than it would if combined with nitro-glycerine. It was also thought that gun-cotton of a high degree of nitration when made into colloidal form would even then burn too quickly to be suitable for use in firearms. Consequently, the first experiments were with low grade gun-cotton, what is called collodion cotton, such as is employed in the manufacture of celluloid. But, as this would not explode without the addition of some oxygen-bearing element, various oxygen-bearing salts were combined with it, such as nitrate of potassium, nitrate of ammonia, nitrate of baryta, etc. Also a great many of the first smokeless powders were made of low grade gun-cotton combined with nitro-glycerine in varying proportions. These powders would often give very good results when first made; but low grade gun-cotton or di-nitro-cellulose, as it is called, is a very unstable compound, and these powders, after giving very promising results, were found to be constantly undergoing change, sooner or later resulting in complete decomposition.

When nitro-glycerine was first combined with gun-cotton in small quantities, camphor was often added, to lessen the rapidity of combustion which the nitro-glycerine was supposed to impart and also to render the compound more plastic, and to tend to prevent the decomposition of the low grade gun-cotton. But camphor being volatile, would, by its evaporation, cause the powder to constantly change in character. Castor oil has been found to be a better diluent, as this will not evaporate.

As all of the smokeless powders made of a low grade gun-cotton were found to deteriorate and spoil, experiments were made with gun-cotton of the highest degree of nitration, both alone and in combination with nitro-glycerine. These experiments were first conducted in England by private parties and by the British government, when it was found that high grade gun-cotton would give excellent results if made into a colloidal solid and used alone, or in combination with certain other constituents. With a view to saving the large quantity of solvents necessary to reduce the gun-cotton, and to get a more prompt and certain ignition with a larger grain, experiments were cautiously made by the admixture of varying proportions of nitro-glycerine to the gun-cotton when dissolved, or rather along with other solvents in the process of dissolving it.

It was soon found that nitro-glycerine added in quantities, even equal in weight to the gun-cotton itself, did not materially increase the rapidity of the explosion of the compound. And it was also found that high grade gun-cotton, when combined with nitro-glycerine, gave very much better results than low grade gun-cotton.

I have spoken here of high and low grade gun-cotton, when in fact the word gun-cotton should be applied only to the highest nitro-compound of cellulose. The word gun cotton has always been rather loosely used. Pyroxyline would be a better word, as this applies to all grades. When cotton fiber is soaked in a large excess of a mixture of the strongest nitric and sulphuric acids, gun-cotton proper, or that of the highest grade, is produced. When weaker acids are used, lower grades of nitro-cellulose are formed.

The first mentioned or highest grade gun-cotton, when thoroughly freed from its acids, has always proved to be a perfectly stable compound. The lower grades have always been found to be unstable and subject to spontaneous decomposition. Nitro-glycerine has also been erroneously thought to be a very unstable compound. But experiments have proved that, when made pure, it is perfectly stable.

Having now explained how the knowledge came to be arrived at that the aforementioned compound of highest grade nitro-glycerine and highest grade gun-cotton would constitute the best basis for a smokeless powder, I will now mention a few of the other conditions necessary to success with its use, without assuming that smokeless powder has yet passed its experimental stage, and is beyond further improvement. Nevertheless, such is the compound which has come to stay as the basis of all smokeless powders; and any smokeless powder, if a successful one, may be counted upon as being made of this compound of gun-cotton and nitro-glycerine, or of a colloid of gun-cotton, either alone or combined with diluents, oxygen-bearing salts, or inert matter. The fact that smokeless powder may still be said to be in somewhat of an experimental stage is not to admit that it is not a success. Firearms, cartridge cases, and projectiles are also still in an experimental stage, for they are constantly being improved; yet their use has been a great success for a good many years.

The question of success of a smokeless powder does not rest alone with the powder itself. The gun, the cartridge case, primer, and bullet have been as much the subjects of experiments in adapting them to the use of smokeless powder as has the smokeless powder in being adapted to them. To impart a velocity of 2,000 feet per second to a rifle ball, with corresponding long range and accuracy of flight, has been a question as much of improvement in rifles and projectiles as in the powder. To give a velocity of 2,000 feet per second to a bullet, requires a pressure of at least 15 English tons in the chamber of a gun. This would be a dangerous pressure in an old-fashioned shoulder arm; while a bullet made only of lead would strip on striking the rifling and pass right through the barrel of the gun without taking any rotary motion whatever. It might at first seem that the powder is the only thing to be considered; but high ballistics can only be obtained when everything else is adapted to its use.

The projectile, the cartridge case, the fulminating cap, and the gun have had to be all built up together, and a very large amount of experimenting has been necessary to determine what would constitute the best projectile, best cartridge case, best fulminating cap, and what should be the character of the rifling and the quality and temper of the steel of the gun barrel.

It has been necessary first to conduct experiments to test the smokeless powders for velocities and pressures, and then with the powders test various kinds of projectiles and guns. In order to obtain the high ballistics which have been secured, it has been found necessary to cover the bullet with something harder than lead and to rifle the gun in a special manner.

The French, who were the first to definitely adopt smokeless powder, were the first also to make a rifle, projectile, cartridge case and primer suited to its use.

To obtain long range with a small long bullet such as is now used, it should rotate at a very high speed. It is well known to artillerists that a projectile of four or more calibers in length has to be rotated at a much higher speed than one of half that length, in order to keep the projectile stiff in the air, and to prevent it from ending over in its flight. To communicate this very high rotary movement to the bullet in the instant of time during which it is passing through the barrel, the rifling of the gun has to exert an enormous torsion on the bullet. Lead, no matter how hardened, is not sufficiently strong, as it will not only strip and pass straight through the gun without taking any rotary movement whatever, but under such very high pressures it behaves like wax, and is thrown from the gun in a distorted mass.

The French cover their bullets with German silver, a substance made of nickel, zinc and copper; and in order to put as little strain upon the rifling and projectile as possible, the rifling of the gun is made with an increasing twist, and has no sharp edges. The French rifle is made very strong at the breech and is of tempered steel throughout. In this way the French have made smokeless powder a success—a smokeless powder made substantially of a character such as I have herein described. With smokeless powder, the French rifle imparts a muzzle velocity of 2,000 feet per second to the bullet, with a range of about 2,400 meters.

If smokeless powder be divided into sufficiently small grains to be ignited by an ordinary fulminating cap, it would burn too quickly, thereby causing the pressure to mount too high, and without giving the desired velocity. Consequently very large and strong fulminating caps have to be employed. Smokeless powder is not ignited in the same manner as black powder. Something besides ignition is necessary. Black powder simply requires to be set on fire; while a smokeless powder, on the contrary, not only requires that it be set on fire, but that a certain degree of pressure be set up inside of the cartridge case. For instance, if a primer of a certain size should be found to operate perfectly well, giving prompt ignition in the cartridge case of a rifle of small caliber, it would be found that the same primer would not ignite a charge of the same powder if loaded into a gun of one inch caliber. In the latter case a few grains only lying near the primer would be ignited, and these would soon become extinguished by sudden release of pressure bringing about a cooling effect due to expansion of the gases. In small cartridges a large fulminating cap is all that is required, but in large cartridges it is necessary to resort to additional means of ignition.

In France, where experiments were conducted with a 37 millimeter Maxim gun, it was found to be impracticable to use a fulminating cap sufficiently large to ignite the powder and cause it to burn. Therefore, a small ignition charge of black powder was employed, it being put in a capsule or bag and placed next the primer. On firing at the rate of 300 rounds per minute, the black powder, though small in quantity, produced a cloud of smoke through which it was quite impossible to see. The inventor of the gun then prepared for the French some wafers of pyroxyline canvas, which were placed next to the primer, securing thereby prompt ignition without the production of any smoke.

Smokeless powder, made as I have described, cannot be detonated by a fulminating cap of any size or by any means whatever. A large charge of fulminate of mercury placed inside the cartridge case next the primer will not detonate the powder, it serving only to ignite it and cause it to explode. But even this would not cause the powder to explode except it be confined behind a projectile, that sufficient pressure may be run up to make it burn in its own gases.

Some curious experiments with smokeless powder may be tried with a shot gun. If the fulminating cap be large, the powder fine, the wads numerous and hard and the charge of shot heavy, all being well rammed down, and the paper case well spun over the last pasteboard wad, a charge of smokeless powder about equal in weight to one-half of what would be employed of black powder would give about the same results as black powder. But if the charge of shot be omitted, the primer will only ignite the powder, and there will be set up sufficient pressure merely to throw the wads about half way up the barrel of the gun, when the powder will go out. Now if this same charge of powder be collected and reloaded into a new cartridge case and well confined behind wads and a charge of shot, as above explained, it will all burn, giving the same results as black powder.

Attempts have been made to use this powder in pistols and revolvers, but here it has proved a failure, as the pressure is not great enough to cause the powder to be consumed, unless it be in the form of very fine grains or dust, in which case the pressure mounts too high. However, this might be overcome to a degree by making the powder porous. The chemical conditions of the powder might be the same, but the physical conditions must be different. A powder suitable for shot guns and pistols would not be suitable for rifles.

One not familiar with the characteristics of smokeless powder would be almost certain to fail in his first attempt to fire it. Many persons have been convinced by their first experiments that this powder would not burn at all in a gun, any more than so much sand.

Smokeless powder is consumed with a rapidity which accords with the conditions of its confinement. Therefore, the bullets which have been experimented with by different governments have been the cause of much of the varying pressures attributed to the smokeless powders.

The Austrians use the Mannlicher steel jacketed bullet. The steel casing or jacket is first tinned on the inside and then the lead is cast in, thus melting the tin and adhering firmly to the jacket. This projectile sets up enormous friction in the barrel of the gun when used with smokeless powder; as the smokeless powder leaves the gun barrel perfectly clean and the two steel surfaces being in absolute contact cause tremendous friction; and as the coefficient of friction varies with every shot, the pressure in the gun constantly varies greatly.

The German silver covered bullet used by the French has the disadvantage that when firing rapidly the chamber of the barrel becomes nickel plated and great friction is caused, mounting up the pressures and causing the muzzle velocities to fall off.

The Austrians, in order to prevent their steel cased bullets from rusting and to lessen the friction in the barrel of the gun, cover them with a heavy lubricant, which gives the cartridges an unsightly appearance and causes them to gather dust and sand.

The French employ a lubricant at the base of the projectile, with a small copper disk between the same and the powder.

Col. A. R. Buffington, commander of the National Armory at Springfield, Mass., has made a steel covered projectile which he prevents from rusting by blackening by a niter process. Several grooves are pressed in the base of the bullet which carry a lubricant, and when the bullet is inserted in the cartridge case the grooves are covered by it. Furthermore, these grooves prevent the lead filling from bursting through the steel casing, leaving the latter in the barrel, as often occurs with the Austrian and French projectiles when using smokeless powder.

A new projectile has lately come out, the invention of Captain Edward Palliser, of the British army. This bullet consists of a jacket made of very soft Swedish wrought iron, coated with zinc and filled with lead, the lead being pressed into this jacket. The bullet is corrugated at its base, after the manner of the one made by Colonel Buffington. This projectile has been experimented with very extensively by the British government, and at the works of the Maxim-Nordenfelt Guns and Ammunition Company, in England. The zinc coating of the bullet is too soft to stick to the barrel of the gun, and also in a measure acts as a lubricant. This projectile has given better results than any other that has been experimented with. The great velocities and the most uniform pressures by the use of smokeless powder have been attained with this Palliser bullet.

NOISELESSNESS.

A great many stories have been told about the noiselessness of smokeless powder. But there is no such thing as a noiseless gunpowder. The report of a gun charged with smokeless powder is very sharp, and is as loud as when black powder is used, yet the volume of sound is much less, so that the report cannot be heard at so great a distance.

The report of a gun using smokeless powder is a sound of much higher pitch than when black powder is used, and consequently cannot be heard at so great a distance as the lower notes given by black powder.

As smokeless powder exerts a much greater pressure than common black powder when burned in a gun, one would naturally think that the recoil of the barrel would be greater, owing to the greater pressure exerted by the smokeless powder on the base of the cartridge case and the breech mechanism. However, such is not the fact; for the barrel actually recoils very much less when smokeless powder is used. This is due to the suddenness with which the pressure is exerted by smokeless powder, it acting more like a very sharp blow on the metal, whereby more of the energy is converted into heat instead of being spent in overcoming the inertia of the barrel to give recoil. Similarly when smokeless powder is fired in a gun, the displacement of the air is so sudden that the sound waves do not possess the same amplitude of recoil or vibration as is given by black powder.

THE CONSTRUCTION AND MAINTENANCE OF UNDERGROUND CIRCUITS.

By S. B. FOWLER.

THE numerous disastrous storms of the last winter have brought out very vividly the advantages of having all wires placed underground, and many inquiries have been addressed to the companies operating underground circuits as to their success. It is not probable that all of the answers to these inquiries have been of the most favorable character. To many central station managers an underground system means frequent break-downs and interruptions of service, with, perhaps, slow and expensive repairs, which bring in their turn numerous complaints, loss of customers, and reduced profits. In many installations burn-outs both underground and in the station are frequent, with the natural result that the operating of circuits underground is not there considered an unqualified success. The writer has in mind two very different experiences with underground cables. Several miles of cable were bought by a certain company, carefully laid, and up to to-day not a single burn-out or interruption of service can be attributed to failure of cables; at about the same time another company bought about an equal amount of the same kind of cable, and in a comparatively short time the current had to be shut off the lines and the whole installation repaired and parts of it replaced. Both of these experiences have been repeated many times and will be again, although it is simply a distinction between a good cable properly laid and a good cable ruined by careless and incompetent workmanship.

Every failure can be traced to poor work in the original installation or to the use of a cheap cable, both causes being due, generally, to that false economy which looks for too quick returns. A poorly insulated line wire and a poorly insulated cable are two very different things. However, it is a fact that by the use of a good cable it is not difficult to construct an underground system for light, power, telegraph or telephone uses that will be superior to overhead lines in its service and in cost of maintenance. The ideal underground system must have as a starting point a system of subways admitting of the easy drawing in and out of cables and affording means of making subsidiary connections readily and with the minimum of expense and interruption of service. This is practically accomplished by a subway consisting of lines of pipe terminating at convenient intervals, say at street intersections, in manholes, for convenience in jointing and in running out house connections. These pipes, or ducts, as they are called, should be for two kinds of service; the lower or deeper laid lines for the main or trunk circuits, and a second series of ducts laid nearer the surface, running into service boxes placed near together for lines to "house to house" connections. In some cities where it is allowed to run overhead lines, the plan of running but one service connection in a block is followed, all customers in the block being supplied from a line run over the housetops or strung on the rear walls.

This makes unnecessary all subsidiary ducts except a short one from the manhole to the nearest building in the block, and effects a considerable saving in pipe, service boxes, cables and labor. The manholes should have their walls built up of brick, the floors should be of concrete, and there should be an inside lid which can be fastened down and the manhole thus made water-tight.

For ducts wood, iron or cement lined pipe may be used. To preserve the wood it is generally treated with creosote, which, in contact with the lead cover of the cable, sets up a chemical action, resulting in the destruction of the lead. Wood offers but little protection for the cable, as it is too easily damaged and broken through in the frequent street openings made by companies operating lines of pipe in the streets, and as one of the main purposes of a subway is that of a protection to cables, wooden ducts have little to recommend them except their cheapness.

Iron pipes are either laid in trenches filled in with earth or are laid in cement. Iron pipe will of course rust out in time, and if absolute permanence in construction is desired, should be laid in cement, for after the pipe rusts out, the duct of cement is still left. However, if we are going to the expense of laying in cement, it would be much preferable to use cement lined pipe, which is not only cheaper than iron pipe, but makes the most perfect cable conduit, as it affords a perfectly smooth surface to draw the cable over and give a good duct edge.

It is not necessary, however, in small installations of cable, especially where additional connections will not be of frequent occurrence, to go to the expense of subways, for cable may be safely laid in the ground in trenches filled in with earth, or can be inclosed in a plain wooden box or a wooden box filled with pitch.

There are, of course, many localities where, if the cable is laid in contact with the earth, a chemical action would take place which might result in the destruction of the cable.

Underground cables are of the following classes: 1. Rubber insulated cables, insulated with rubber or other homogeneous material. 2. Fibrous cables, so called from the conductors being covered with some fibrous material, as cotton or paper, which is saturated with the insulating material, paraffine, resin oil, or some special compound. Under this latter head is also included the dry core paper cables.

The first thing to do is to get the cable drawn into the ducts, and on the proper accomplishment of this depends to a great extent the success or failure of the whole installation. Probably the ducts have been wired when the subway was constructed, but if not a wire must be run through as a means of pulling in the draw rope. There are several kinds of apparatus for getting a wire through a duct—rods, flexible tapes, mechanical "creepers," etc.; but probably the best is the sectional rod. This simply consists of three or four foot lengths of hard wood rods, having metal tips that screw into each other. A rod is placed in a duct at a manhole, one screwed to that, both are pushed forward, another one added and pushed forward, and so on until they extend the entire length of the duct. Then the wire is attached and the rods are pulled out and detached one at a time and with the last rod the wire is through. At least No. 14 galvanized iron or steel wire should be used, for any smaller size cannot be used a second time, as a rule. In starting to pull in the draw rope a wire brush should be attached to the wire and to this again the rope, and when the brush arrives at the distant end of the duct it very likely will bring with it a miscellaneous collection of material which for the good of the cable had better be in the manhole than in the duct.

The reel or drum carrying the cable should be mounted on wheels or jacks and placed on the same side of the manhole as the duct into which the cable is to be drawn, and must always be so placed that the cable will run off the top of the reel.

There are several methods of attaching the draw rope to the cable. As simple and strong a method as any is to punch two of these holes through the cable, lead and all, and attach the rope by means of an iron wire—some of the draw wire will do—run through these holes. Depending on the length and weight of cable to be pulled it can be drawn either by hand or by a multiplying winch. The rope should run through a block fastened in the manhole in such a position that the rope shall have a good straightaway lead from the mouth of the duct.

The strain on the cable should be perfectly uniform and steady; if the power is applied by a series of jerks either the lead covering may be pulled apart or some of the conductors broken. At the reel there must always be a large enough number of men to turn it and keep the cable from rubbing on anything, and in the manhole one or more men to see that the cable feeds into the duct straight and to guide it if necessary. If the ducts are of iron and are not perfectly smooth at the ends, these should be made so with a file, and in addition a protector of some sort should be placed in the mouths of the duct, both above and below the cable. Six inches of lead pipe, split lengthwise and bent over at one end to prevent being drawn into the duct with the cable, makes a very good protector. The cable should be reeled off the drum just fast enough to prevent any of the power used in pulling the cable through the duct being utilized in unreeling it. If this latter is allowed to occur the cable will be bent too short and the lead covering buckled or broken, and also the cable may be jammed against the upper edge of the duct and perhaps cut through.

If the reel is allowed to turn faster than the cable is drawn in, the first three or four turns on the reel will slacken up, and the lead covering may either be dented or cut through by scraping on the ground. If the cable end when pulled through up to the block is not long enough to bend around the hole more than half way, the rope should be unfastened from its end, a length of rope with a well frayed out end should be run through the block, and by fastening to the cable close to the duct, with a series of half hitches, as much slack as necessary can be pulled in. If this is properly manipulated there need not be a scratch on the cable, but unless great care is taken the lead may be pressed up into ridges and the core itself damaged.

Immediately after the cable is drawn in, if the joint is not to be at once made, the open end or ends should be cut off and the cable soldered up, as most cables are very susceptible to moisture and readily absorb water even from the atmosphere. Where practicable it is always a good plan to pull the cable through as many manholes as possible without cutting the cable; for the joint is, especially in telephone or telegraph cables, the weak point. To do this the rope should be pulled through the proper duct in the next section without unfastening it from the cable; the winch should be moved to the next manhole, and pulling through then done as before. There should always be a man in every hole through which the cable is running to see that it does not bind anywhere and to keep protectors around the cable.

It is not advisable to pull more than one cable into a duct, and never advisable to pull a cable into a duct containing another cable, but if two or more cables have to go into the same duct, they should always be drawn in together. Lead covered cables and those with no lead on the outside should never be pulled into the same duct, for if they bind anywhere the soft cable will suffer where two lead covered cables would get through all right. Some manufacturers are now putting on their cables a tape or braid covering, which saves the lead many bad bruises and cuts, and is a valuable addition to a cable at very little additional expense.

Practically all electric light and power cables are either single or double conductors, and the jointing of these is comparatively a simple matter, although requiring considerable care. The lead is cut back from each end about four or five inches, and the conductors bared of insulation for two or three inches. The bare conductors should be thoroughly tinned by dipping in the metal pot or pouring the melted solder over them. A sperm candle is better than resin or acid for any part of the operations where solder is used. A lead sleeve is here slipped back over the cable, out of the way, and the ends of the conductors brought together in a copper sleeve which is then sweated to a firm joint. This part must be as good a piece of work mechanically as electrically. The bare splice is then wrapped tightly with cotton or silk tape to a thickness slightly greater than that of the insulation of the cable, and is thoroughly saturated with the insulating compound until all moisture previously absorbed by the tape is driven off.

The lead sleeve is then brought over the splice and wiped to the cable. The joint is then filled with the insulating compound poured through holes in the top of the sleeve; these holes are then closed and the joint is complete, and there is no reason why, in light and power cables, that joint should not be as perfect as any other part of the cable. When the cable ends are prepared for jointing they should be hung up in such a position that they are in the same plane, both horizontal and vertically, and firmly secured there, so that when the lead sleeve is wiped on the conductor may be in its exact center, and great care must be taken not to move the cables again until the sleeve is filled and the insulation sufficiently cooled to hold the conductor in position.

It is also very important to see that there are no sharp points on the conductors themselves, on the copper sleeve, on the edges of the lead covering or on the lead sleeve. All these should be made perfectly smooth, for points facilitate disruptive discharges. Branch joints had better be made as T-joints rather than as Y-joints, for they are better electrically and mechanically, although they occupy more room in the manholes. They are of course made in the same way as straight joints, a lead T-sleeve being used, however. For multiple arc circuits copper T-sleeves and for series circuits copper L-sleeves are used.

Telephone and telegraph cables are made of any required gauge of wire and with from 1 to 150 conductors in a cable. In jointing these the splices are never soldered, the conductors being joined either with a twist joint or with the so-called Western Union splice. Each splice is covered with a cotton or silk sleeve or a wrapping of tape, the latter being preferable, although considerably increasing the time necessary for making the joint. Great care must be taken that no ends of wire are left sticking up, for they will surely work their way through the tape and grounds, and crosses will be the result. The wires should always be joined layer to layer and each splice very tightly taped in order to get as much insulating compound around each splice as possible in the limited space. The splices should be "broken" as much as possible, so as to avoid having adjoining splices coming over each other. After the joint has been saturated with insulating compound the wires should have an outside wrapping of tape to keep them in shape, and then the sleeve is wiped on and filled. If the insulation resistance of the jointed telegraph or telephone cable is a quarter of what the cable tested in the factory, it may be considered that an exceptionally good piece of work has been done. I have spoken more particularly of fibrous lead covered cables, as the handling of them includes practically every step of the work on any other kind of underground cable. In insulating dry core paper cables a paper sleeve is slipped over the splice, and in rubber cables the splice is wrapped with rubber tape; all other details are the same for these as for the fibrous cable.

In the laying of light and power cables every joint, as made, should be tested for insulation with a Thomson galvanometer, as the insulation must necessarily be very high, and if one joint or section of cable is any weaker than another it may be very important in the future to know it. All tests must be made after the joint has cooled, for while hot its insulation resistance will be very low.

Tests for copper resistance should also be made to determine if the splices are electrically perfect; an imperfect splice may cause considerable trouble. In telegraph and telephone cables the conductors should be of very soft copper, for in stripping the conductor of insulation it is very easy to nick the wire, and if of hard drawn copper open wires will be the result.

All work should be frequently tested for continuity with telephones, magnetos, or small portable galvanometers. It is only necessary to ground the conductors at one end and try each wire at the other end. For this sort of work a telephone receiver used with one cell of some dry battery is most convenient, and has the additional advantage of affording a means of communication while testing, and is by far the best thing for identifying and tagging conductors.

These cables should be frequently tested during the progress of the work for grounds and crosses with a Thomson instrument, and when the cable is complete, a careful series of tests of the capacity, insulation resistance, and copper resistance of each wire should be made and the exact condition of the cable determined before it is put in service, and thereafter an intelli-

gent oversight of the condition of the circuits can thus be more readily maintained.

Where a company has extensive underground service, a regular cable gang should be in its employ, for quick and safe handling of cables demands the employment of men accustomed to the work. If the cable has been properly laid and tests show it to be in good condition before current is turned on, almost the only trouble to be anticipated will be due to mechanical injury. Disruptive discharge, puncturing the lead, may occur; but the small chance of its occurring can be greatly lessened by the use of some kind of "cable protector," which will provide for the spark an artificial path of less resistance than the dielectric of the condenser, which the cable in fact becomes.

If a fault suddenly develops on a circuit, the chances are it will be found in a manhole, and an inspection of the cable in the manhole will generally reveal the trouble without resorting to locating with a Wheatstone bridge. The cable is often cut through at the edge of the duct, or damaged by something falling on it, or by some one "walking all over it." To guard against these, the ducts should always be fitted with protectors both above and below the cable. The cables should never be left across the manholes, for they then answer the purpose of a ladder, but should be bent around the walls of the hole and securely fastened with lead straps, that they may not be moved and the lead gradually worn through.

In telegraph cables, when one or two conductors "go," it will probably be useless to look for trouble except with instruments; but if several wires are "lost" at once it will probably be found to be caused by mechanical injury, which can be located by inspection. If it is ever necessary to loop out conductors, a joint can be readily opened and the conductors wanted picked out and connected into the branch cable and the joint again closed without disturbing the working wires. In doing this a split sleeve must be used, and the only additional precaution to be taken is in filling the sleeve to have the insulating compound not hot enough to melt the solder and open up the split in the sleeve. In cutting in service on light and power cables it is entirely practicable to do so without interruption of service on multiple arc circuits, even those of very high voltage; but they require great precaution and involve considerable risk to the jointer, and where possible the circuit to which the connection is to be made should previously be cut dead. Where the voltage is not dangerous to human life, almost any service connection can be made without interruption of service.

I have only indicated a very few of the operations that may be found necessary, and the probable causes of troubles that may be encountered in the operating of underground circuits, believing that the different problems that arise can, with a little experience, be successfully met by any one who has a fair knowledge of the original construction of cable lines.—*Electrical World.*

RAILROADS TO THE CLOUDS.

If George Stephenson, when he placed the first locomotive on the track and guaranteed it a speed of six miles an hour, could have foreseen that in less than eighty years the successors of his rude machine would be climbing the sides of mountain ranges, piercing gorges hitherto deemed inaccessible, crossing ravines on bridges higher than the dome of St. Paul's, and traversing the bowels of the earth by means of tunnels, no doubt his big blue eyes would have stood out with wonder and amazement. But he foresaw nothing of the kind; the only problem present in his mind was how to get goods from the seaports in western England to London as easily and cheaply as possible, and to do this he substituted for horses, which had for 150 years been drawing cars along wooden or iron tracks, the wonderful machine which has revolutionized the freight and passenger traffic of the world.

It was, indeed, impossible for any one to foresee the triumphs of engineering which have accompanied the advances in transportation. To the engineer of the present day there are no impossibilities. The engineer is a wizard at whose command space and matter are annihilated. The highest mountain, the deepest valley, has no terrors for him. He can bridge the latter and encircle or tunnel the former. The only requisites which he demands are that something in his line be needed, and that the money is forthcoming to defray the expense, and the thing will be done. But the railroad he is asked to construct must be necessary, and the necessity must be plainly shown, or no funds will be advanced; and although the theory does not invariably hold good, especially when a craze for railroad building is raging, as a rule no expense for the construction of a road will be incurred without a prospect of remuneration.

Hence the need of railroad communication has caused lines to be constructed through districts where only a few years ago the thing would have been deemed impossible. The Pacific roads of this country were a necessity long before their construction, and in the face of difficulties almost insuperable were carried to successful completion. So, also, of the railroads in the Andes of South America. The famous road from Callao through the heart of Peru is one of the highest mountain roads in the world, as well as of the most difficult construction. The grades are often of 300 feet and more to the mile, and when the mountains were reached so great were the difficulties the engineers were forced to confront that in some places laborers were lowered from cliffs by ropes in order that, with toil and difficulty, they might carve a foothold in order to begin the cutting for the roadway.

In some sections tunnels are more numerous than open cuts, and so far as the road has gone sixty-one tunnels, great and small, have been constructed, aggregating over 20,000 feet in length. The road attains a height of 15,000 feet above the level of the sea, and at the highest point of the track is about as high as the topmost peak of Mont Blanc. It pierces the range above it by a tunnel 3,847 feet long. The stern necessities of business compelled the construction of this road, otherwise it never would have been begun.

The tunnels of the Andes, however, do not bear comparison with the tunnels, bridges, and snow sheds of the Union Pacific, nor do even these compare with the vast undertakings in the Alps—three great tunnels of nine to eleven miles in length, which have been prepared for the transit of travelers and freight. The requirements of business necessitated the piercing of the Alps, and as soon as the necessity was shown, funds in abundance were forthcoming for the enterprise.

But tunneling a mountain is a different thing from climbing it. Many years ago the attention of inventors was directed to the practicability of constructing a railroad up the side of a mountain on grades which, to an ordinary engine, were quite impossible. The improvements in locomotives twenty-five and thirty years ago rendered them capable of climbing grades which, in the early days of railroad engineering, were deemed out of the question. The improvements proved a serious stumbling block in the way of the inventors, who found that an ordinary locomotive was able to climb a much steeper grade than was commonly supposed. The first railroads were laid almost level, but it was soon discovered that a grade of a few feet to the mile was no impediment to progress, and gradually the grade was steepened.

The inventors of mountain railroad transportation might have been discouraged by this discovery, but it is a characteristic of an inventor that he is not set back by opposition, which, in fact, only serves to stimulate his zeal. The projectors of inclined roads and mountain engines kept steadily on, and in France, Germany, England, and the United States many experimental roads were constructed, each of a few hundred yards in length, and locomotive models were built and put in motion to the amazement of the general public, who jeered alike at the contrivances and the contrivers, deeming the former impracticable and the latter crazy.

But the idea of building a road up the side of a hill was not to be dismissed. There was money in it for the successful man, so the cranky inventors kept on at work in spite of the jeers of the rabble and the discouragements of capitalists loath to invest their money in an uncertain scheme. To the energy and perseverance of railroad inventors the success of the mountain railroad is due, as also is the construction of the various mountain roads, of which the road up Mt. Washington, finished in 1868, was the first, and the road up Pike's Peak, completed the other day, was the latest.

Of all the mountain roads which have been constructed since the one up Mt. Washington was finished, the best known is that which ascends the world-famous Rigi. With the exception of Mont Blanc, Rigi is, perhaps, the best known of any peak in the Alps, though it is by no means the highest, its summit being but 5,905 feet above the level of the sea. Although scarcely more than a third of the height of some other mountains in the Alps, it seems much higher because of its isolated position. Standing as it does between lakes Lucerne, Zug, and Lowertz, it commands a series of fine views in every direction, and he who looks from the summit of Rigi, if he does no other traveling in Switzerland, can gain a fair idea of the Swiss mountain scenery. Many of the most noted peaks are in sight, and from the Rigi can be seen the three lakes beneath, the villages which here and there dot the shores, and, further on, the mighty Alps, with their glaciers and eternal snows.

Many years ago a hotel was built on the summit of the Rigi for the benefit of the tourists who daily flocked to this remarkable peak to enjoy the benefit of its wonderful scenery. The mountain is densely wooded save where the trees have been cut away to clear the land for pastures. The ease of its ascent by the six or eight mule paths which had been made, the gradual and almost regular slope, and the throngs of travelers who resorted to it, made it a favorable place for an experiment, and to Rigi went the engineers in order to ascertain the practicability of such a road. The credit of the designs is due to a German engineer named Regenbach, who, about the year 1861, designed the idea of a mountain road, and drew up plans not only for the bed but also for the engine and cars. The scheme dragged. Capitalists were slow to invest their money in what they deemed a wild and impracticable undertaking, and even the owners of the land on the Rigi were reluctant for such an experiment to be tried. But Regenbach persevered, and toward the close of the decade the inhabitants of Vitznau, at the base of the Rigi, were astonished to see gangs of laborers begin the work of making a clearing through the forests on the mountain slope. They inquired what it meant, and were told that a road up the Rigi was to be made. The Vitznauers were delighted, for they had no roads, and there was not a wheeled vehicle in the town, nor a highway by which it could be brought thither. The idea of a railroad in their desolate mountain region, and, above all, a railroad up the Rigi, never entered their heads, and a report which some time after obtained currency in the town, that the laborers were beginning the construction of a railroad, was greeted with a shout of derision.

Nevertheless, that was the beginning of the Rigi line, and in May, 1871, the road was opened for traffic. It begins at Vitznau, on Lake Lucerne, and extends to the border of the canton and almost to the top of the mountain. It is 19,000 feet long, and during that distance rises 4,000 feet at an average grade of 1 foot in 4. Though steep, it is by no means so much so as the Mt. Washington road, which rises 5,285 feet above the sea, at an average of 1 foot in 3. There are, however, stretches of the Rigi road at which the grade is about 1 foot in 2½, which is believed to be the steepest in the world.

The Rigi road has several special features aside from its terrific slopes which entitle it to be considered a triumph of the engineer's skill. About midway up the mountains the builders came to a solid mass of rock, which presented a barrier that to a surface road was impassable. They determined to tunnel it, and, after an enormous expenditure of labor, finished an inclined tunnel 225 feet in length, of the same gradient as the road. A gorge in the side of the mountain where a small stream, the Shnurtobel, had cut itself a passage also hindered their way, and was crossed by a bridge of lattice girder work in three spans, each 85 feet long. The entire roadbed, from beginning to end, was cut in the solid rock. A channel was chiseled out to admit the central beam, which contains the cogs fitting the driving wheel of the locomotive. The engine is in the rear of the train, and presents the exceedingly curious feature of a boiler greatly inclined, in order that at the steeper gradients it may remain almost perpendicular. The coal and water are contained in boxes over the driving wheels, so that all the weight of the engine is really concentrated on the cogs—a precaution to prevent their slipping. The cost of the road, including three of these strangely constructed locomotives, three passenger coaches, and three open wagons, was $260,000, and it is a good paying investment. The fare demanded for the trip up the mountains is 5 francs, while half that sum is required for the downward passage, and the road is annually traversed by from 30,000 to 50,000 passengers.

Curious sensations are produced by a ride up this remarkable line. The seats of the cars are inclined like the boiler of the locomotive, and so long as the cars are on a level the seats tilt at an angle which renders it almost impossible to use them. But when the start is made the frightful tilt places the body in an upright position, and, with the engine in the rear, the train starts up the hill with an easy, gliding motion, passing up the ascent, somewhat steeper than the roof of a house, without the slightest apparent effort. But if the going up excites tremor, much more peculiar are the feelings aroused on the down grade. The trip begins with a gentle descent, and all at once the traveler looking ahead sees the road apparently come an end. On a nearer approach he is undeceived and observes before him a long decline which appears too steep even to walk down. Involuntarily he catches at the seats, expecting a great acceleration of speed. Very nervous are his feelings as the train approaches this terrible slope, but on coming to the incline the engine dips and goes on not a whit faster than before and not more rapidly on the down than on the up grade. Many people are made sick by the sensation of falling experienced on the down run. Some faint, and a few years ago one traveler, supposed to be afflicted with heart disease, died of fright when the train was going over the Schnurtobel bridge. The danger is really very slight, there not having been a serious accident since the road was opened. The attendants are watchful, the brakes are strong, but even with all these safeguards, men of the steadiest nerves cannot help wondering what would become of them in case anything went wrong.

Bold as was the project of a railroad on the Rigi, a still bolder scheme was broached ten years later, when a daring genius proposed a railroad up Mt. Vesuvius. A railroad up the side of an ordinary mountain seemed hazardous enough, but to build a line on the slope of a volcano, which in its eruption had buried cities, and every few years was subject to a violent spasm, seemed as hazardous as to trust the rails of an ordinary line to the rotten river ice in spring time. The proposal was not, however, so impracticable as it looked. While the summit of Vesuvius changes from time to time from the frequent eruptions, and varies in height and in the size of the crater, the general slope and contour of the mountain are about the same to-day as when Vesuvius, a wooded hill, with a valley and lake in the center of its quiescent crater, served as the stronghold of Spartacus and his rebel gladiators. There have been scores of eruptions since that in which Herculaneum and Pompeii were overthrown, but the sides of the mountain have never been seriously disturbed.

A road on Vesuvius gave promise of being a good speculation. Naples and the other resorts of the neighborhood annually attracted many thousands of visitors, and a considerable number of these every year ascended the volcano, even when forced to contend with all the difficulties of the way. Many, however, desiring to ascend, but being unable or unwilling to walk up, a chair service was established—a peculiar chair being slung on poles and borne by porters. In course of time the chair service proved to be inadequate for the numbers who desired to make the ascent, and the time was deemed fit for the establishment of more speedy communication.

Notwithstanding the necessity, the proposal to establish a railroad met with general derision, but the scheme was soon shown to be perfectly practicable, and a beginning was made in 1879. The road is what is known as a cable road, there being a single sleeper with three rails, one on the top which really bore the weight, and one on each side near the bottom, which supported the wheels, which coming out from the axle at a sharp angle, prevented the vehicle from being overturned. The road covers the last 4,000 feet of the ascent, and the power house is at the bottom, a steel cable running up, passing round a wheel at the top and returning to the engine in the power house. The ascent to the lower terminus of the road is made on mules or donkeys; then, in a comfortable car, the traveler is carried to a point not far from the crater. The car is a combined grip and a passenger car, similar in some points to the grip car of the present day, while the seats of the passenger portion are inclined as in the cars on the Rigi road. But the angle of the road being from thirty-three to forty-five degrees, makes both ascent and descent seem fearfully perilous. Every precaution, however, is taken to insure the safety of passengers; each car is provided with several strong and independent brakes, and thus far no accident worth recording has occurred. The road was opened in June, 1880. Although there have been several considerable eruptions since that date, none of them did any damage to the line but what was repaired in a few hours.

The fashion thus set will, no doubt, be followed in many other quarters. Wherever there is sufficient travel to pay working expenses and a profit on a steep grade mountain road it will probably be built. Already there is talk of a road on Mont Blanc, of another up the Yungfrau, and several have been projected in the Schwartz and Hartz mountains. A route on Ben Nevis, in Scotland, is already surveyed, and it is said surveys have also been made up Snowden, with a view to the establishment of a road to the summit of the highest Welsh peak. Sufficient travel is all that is necessary, and when that is guaranteed, whenever a mountain possesses sufficient interest to induce people to make its ascent in considerable numbers, means of transportation, safe and speedy, will soon be provided. The modern engineer is able, willing and ready to build a road to the top of Mt. Everest in the Himalayas if he is paid for doing so.—*St. Louis Globe-Democrat.*

To clean hair brushes, wash with weak solution of washing soda, rinse out all the soda, and expose to sun.

THE MARCEAU.

THE Marceau, the last ironclad completed and added to the French navy, was put in commission at Toulon in April last, and has lately left that town to join the French squadron of the north at Brest. The original designs of this ship were prepared by M. Huin, of the French Department of Naval Construction, but since the laying down of the keel in the year 1882 they have been very considerably modified, and many improvements have been introduced.

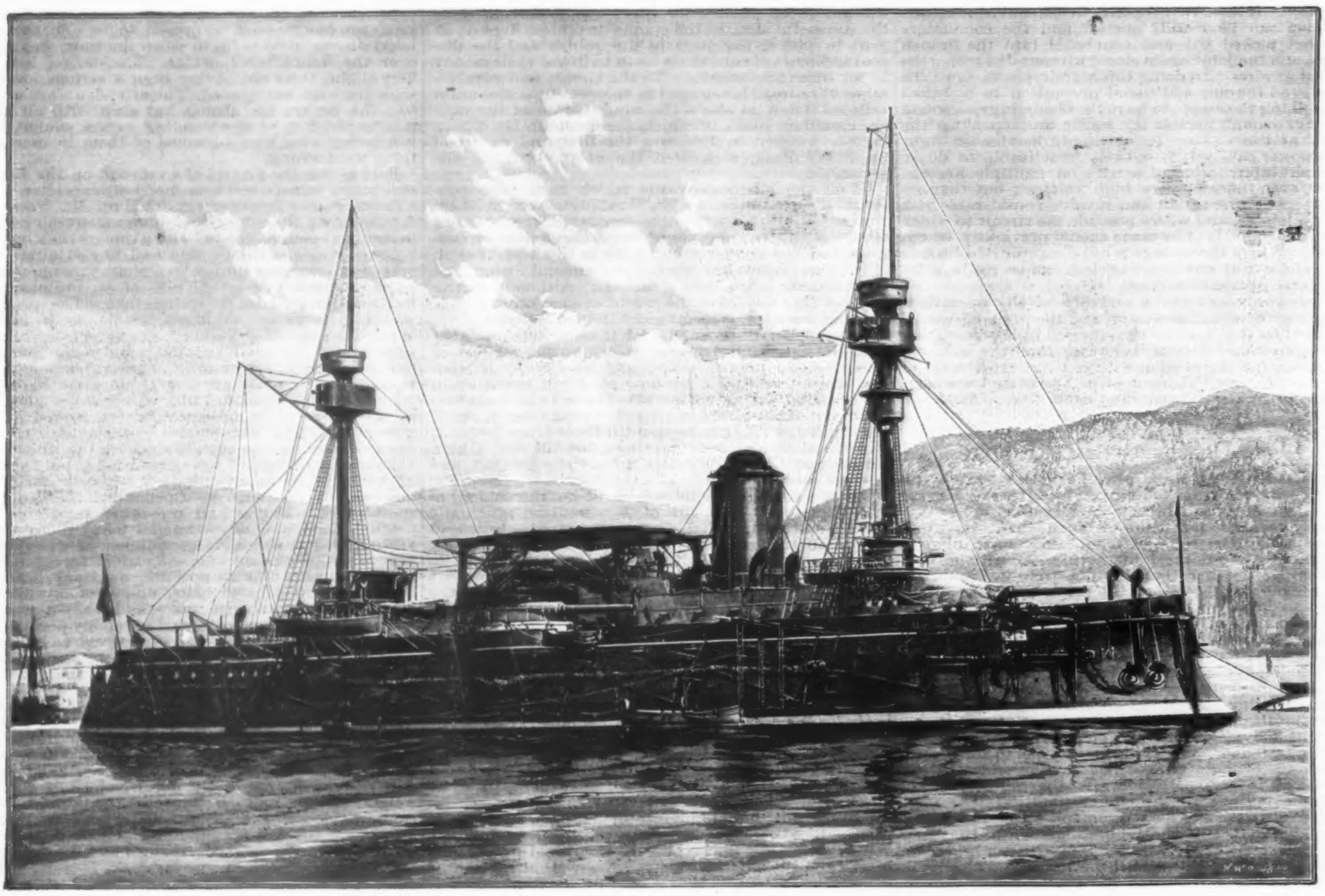
Both ship and engines were constructed by the celebrated French firm, the Société des Forges et Chantiers de la Mediterranée, the former at their shipyard in La Seyne and the latter at their engine works in Marseilles. The ship was five years in construction on the stocks, was launched in May, 1887, and not having been put in commission until the present year, was thus nearly nine years in construction. She is a barbette belted ship of somewhat similar design to the French ironclads Magenta, now being completed at the Toulon arsenal, and the Neptune, in construction at Brest.

The hull is constructed partly of steel and partly of iron, and has the principal dimensions as follows. Length, 330 ft. at the water line; beam, 66 ft. outside the armor; draught, 27 ft. 6 in. att.; displacement, 10,430 English or 10,600 French tons. The engines are two in number, one driving each propeller; they are of the vertical compound type, and on the speed trials developed 11,300 indicated horse power under forced and 5,500 indicated horse power under natural draught, the former giving a speed of 16·2 knots per hour with 90 revolutions per minute. The boilers are eight in number, of the cylindrical marine type, and work at a pressure of 85·3 lb. per square inch. During the trials the steering powers of the ship were found to be excellent, but the bow wave is said, by one critic, to have been very great.

The ship is completely belted with Creusot steel armor, which varies in thickness from 9 in. forward to 17¾ in. midships. In addition to this belt the ship is protected by an armored deck of 3¼ in., while the barbette gun towers are protected with 15¾ in. steel armor with a hood of 2½ in. to protect the men against machine gun fire. As a further means of insuring the life of the ship in combat and also against accidents at sea, the Marceau is divided into 102 water-tight compartments and is fitted with torpedo defense netting. There are two masts, each carrying double military tops; and a conning tower is mounted on each mast, from either of which the ship may be worked in time of action, and both of which are in telegraphic communication with the engine rooms and magazines. Provision is made for carrying 600 tons of coal, which, at a speed of 10 knots, should be sufficient to supply the boilers for a voyage of 4,000 miles.

The armament of the Marceau is good for the tonnage of the ship and consists principally of four guns of 34 centimeters (13·39 in.) of the French 1884 model, having a weight of 52 tons, a length of 28½ calibers, and being able to pierce 30 in. of iron armor at the muzzle. The projectiles weigh 924 lb., and are fired with a charge of 387 lb. of powder. The muzzle velocity has been calculated to be 1,968 ft. per second. The guns are entirely of steel and are mounted on Canet carriages in four barbette towers, one forward, one aft, and one on each side amidships. On the firing trials both the guns and all the Canet machinery, for working the guns and hoisting the ammunition, gave very great satisfaction to all present at the time. In addition to the above four heavy guns there are, in the broadside battery, sixteen guns of 14 centimeters (5·51 in.), eight on each side, and a gun of equal caliber is mounted right forward on the same deck. The armament is completed by a large number of Hotchkiss quick-firing and revolver guns and four torpedo tubes, one forward, one aft, and one on each side.

The crew of the Marceau has been fixed at 600 men, and the cost is stated to have been about $3,750,000.—*Engineering.*



THE FRENCH ARMORED TURRET SHIP MARCEAU.

[Continued from SUPPLEMENT, No. 820, page 13097.]

A REVIEW OF MARINE ENGINEERING DURING THE PAST DECADE.*

By Mr. ALFRED BLECHYNDEN, of Barrow-in-Furness

Steam Pipes.—The failures of copper steam pipes on board the Elbe, Lahn, and other vessels have drawn serious attention both to the material and to the modes of construction of the pipes. The want of elastic strength in copper is an important element in the matter; and the three following remedies have been proposed, while still retaining copper as the material. First, in view of the fact that in the operation of brazing the copper may be seriously injured, to use solid drawn tubes. This appears fairly to meet the main dangers incidental to brazing; but as solid drawn pipes of over 7 inches diameter are difficult to procure, it hardly meets the case sufficiently. Secondly, to use electrically deposited tubes. At first much was promised in this direction; but up to the present time it can hardly be regarded as more than in the experimental stage. Thirdly, to use the ordinary brazed or solid drawn tubes, and to re-enforce them by serving with steel cord or steel or copper wire. This has been tried, and found to answer perfectly. For economical reasons, as well as for insuring the minimum of torsion to the material during manufacture, it is important to make as few bends as possible; but in practice much less difficulty has been experienced in serving bent pipes in a machine than would have been expected. Discarding copper, it has been proposed to substitute steel or iron. In the early days of the higher pressures, Mr. Alexander Taylor adopted wrought iron for steam pipes. One fitted in the Claremont in February, 1882, was recently removed from the vessel for experimental purposes, and was reported upon by Mr. Magnus Sandison in a paper read before the Northeast Coast Institution of Engineers and Shipbuilders. The following is a summary of the facts. The pipe was 5 inches external diameter, and 0·375 inch thick. It was lap welded in the works of Messrs. A. & J. Stewart. The flanges were screwed on and brazed externally. The pipe was not lagged or protected in any manner. After eight and a half years' service the metal measured where cut 0·32 and 0·375 inch in thickness, showing that the wasting during that time had been very slight. The interior surface of the tube exhibited no signs of pitting or corrosion. It was covered by a thin crust of black oxide, the maximum thickness of which did not exceed $\frac{1}{32}$ inch. Where the deposit was thickest it was curiously striated by the action of the steam. On the scale being removed, the original bloom on the surface of the metal was exposed. It would thus appear that the danger from corrosion of iron steam pipes is not borne out in their actual use; and hence so much of the way is cleared for a stronger and more reliable material than copper. So far the source of danger seems to be in the weld, which would be inadmissible in larger pipes; but there is no reason why these should not be lapped and riveted. There seems, however, a more promising way out of the difficulty in the Mannesmann steel tubes which are now being "spun" out of solid bars, so as to form weldless tubes.

TABLE I.—TENSILE STRENGTH OF GUN METAL AT HIGH TEMPERATURES.

Composition of gun metal.	Temperature of oil bath.	Tensile strength per square inch.	Elastic limit per square inch.	Elongation in length of 2 inches.
Per cent.	Fahr.	Tons.	Tons.	Per cent.
Copper 87, Tin 8, Zinc 3½, Lead 1½	50°	12·34	8·38	14·64
	400°	10·83	6·30	11·79
Copper 87, Tin 8, Zinc 5	50°	13·86	8·33	20·30
	458°	10·70	7·43	12·43

Cast steel has been freely used by the writer for bends, junction pieces, etc., of steam pipes, as well as for steam valve chests; and except for the fact that steel makers' promises of delivery are generally better than their performance, the result has thus far been satisfactory in all respects. These were adopted because there existed some doubt as to the strength of gun metal under a high temperature; and as the data respecting its strength appeared of a doubtful character, a series of careful tests were made to determine the tensile strength of gun metal when at atmospheric and higher temperatures. The test bars were all 0·75 in. diameter, or 0·4417 square inch sectional area; and those tested at the higher temperatures were broken while immersed in a bath of oil at the temperature here stated, each line being the mean of four experiments. The result of these experiments was to give somewhat greater faith in gun metal as a material to be used under a higher temperature; but as steel is much stronger, it is probably the most advisable material to use, when the time necessary to procure it can be allowed.

Feed Heating.—With the double object of obviating strain on the boiler through the introduction of the feed water at a low temperature, and also of securing a greater economy of fuel, the principle of previously heating the feed water by auxiliary means has received considerable attention, and the ingenious method introduced by Mr. James Weir has been widely adopted. It is founded on the fact that, if the feed water as it is drawn from the hot well be raised in temperature by the heat of a portion of steam introduced into it from one of the steam receivers, the decrease of the coal necessary to generate steam from the water of the higher temperature bears a greater ratio to the coal required without feed heating than the power which would be developed in the cylinder by that portion of steam would bear to the

* Paper read before the Institution of Mechanical Engineers, July 28, 1891.

whole power developed when passing all the steam through all the cylinders. The temperature of the feed is of course limited by the temperature of the steam in the receiver from which the supply for heating is drawn. Supposing, for example, a triple expansion engine were working under the following conditions without feed heating: Boiler pressure, 150 lb.;—indicated horse power in high pressure cylinder 398, in intermediate and low pressure cylinders together 790, total, 1,188; and temperature of hot well 100° Fahr. Then with feed heating the same engine might work as follows: The feed might be heated to 220° Fahr., and the percentage of steam from the first receiver required to heat it would be 12·2 per cent.; the indicated horse power in the high pressure cylinder would be as before 398, and in the intermediate and low pressure cylinders it would be 12·2 per cent. less than before, or 694, and the total would be 1,092, or 92 per cent. of the power developed without feed heating. Meanwhile the heat to be added to each pound of the feed water at 220° Fahr. for converting it into steam would be 1,005 units against 1,125 units with feed at 100° Fahr., equivalent to an expenditure of only 89·4 per cent. of the heat required without feed heating. Hence the expenditure of heat in relation to power would be 89·4+92·0=97·2 per cent., equivalent to a heat economy of 2·8 per cent. If the steam for heating can be taken from the low pressure receiver, the economy is about doubled. Other feed heaters, more or less upon the same principle, have been introduced. Also others which heat the feed in a series of pipes within the boiler, so that it is introduced into the water in the boiler practically at boiling temperature; this is economical, however, only in the sense that wear and tear of the boiler is saved; in principle the plan does not involve economy of fuel.

Auxiliary Supply of Fresh Water.—Intimately associated with the feed is the means adopted for making up the losses of fresh water due to leakage of steam from safety valves, glands, joints, etc., and of water discharged from the air pumps. A few years ago this loss was regularly made up from the sea, with the result that the water in the boilers was gradually increased in density; whence followed deposit on the internal surfaces, and consequent loss of efficiency, and danger of accident through overheating the plates. With the higher pressures now adopted, the danger arising from overheating is much more serious, and the necessity is absolute of maintaining the heating surfaces free from deposit. This can be done only by filling the boiler with fresh water in the first instance, and maintaining it in that condition. To do this two methods are adopted, either separately or in conjunction. Either a reserve supply of fresh water is carried in tanks or the supplementary feed is distilled from sea water by special apparatus provided for the purpose. In the construction of the distilling or evaporating apparatus advantage has been taken of two important physical facts, namely, that, if water be heated to a temperature higher than that corresponding with the pressure on its surface, evaporation will take place; and that the passage of heat from steam at one side of a plate to water at the other is very rapid. In practice the distillation is effected by passing steam, say from the first receiver, through a nest of tubes inside a still or evaporator, of which the steam space is connected either with the second receiver or with the condenser. The temperature of the steam inside the tubes being higher than that of the steam either in the second receiver or in the condenser, the result is that the water inside the still is evaporated, and passes with the rest of the steam into the condenser, where it is condensed, and serves to make up the loss. This plan localizes the trouble of deposit, and frees it from its dangerous character, because an evaporator cannot become overheated like a boiler, even though it be neglected until it salts up solid; and if the same precautions are taken in working the evaporator which used to be adopted with low pressure boilers when they were fed with salt water, no serious trouble should result. When the tubes do become incrusted with deposit, they can be either withdrawn or exposed, as the apparatus is generally so arranged; and they can then be cleaned.

Screw Propeller.—In Mr. Marshall's paper of 1881 it was said that "the screw propeller is still to a great extent an unsolved problem." This was at the time a fairly true remark. It was true the problem had been made the subject of general theoretical investigation by various eminent mathematicians, notably by Professor Rankine and Mr. William Froude, and of special experimental investigation by various engineers. As examples of the latter may be mentioned the extended series of investigations in the French vessel Pelican, and the series made by Mr. Isherwood on a steam launch about 1874. These experiments, however, such as they were, did little to bring out general facts and to reduce the subject to a practical analysis. Since the date of Mr. Marshall's paper, the literature on this subject has grown rapidly, and has been almost entirely of a practical character. The screw has been made the subject of most careful experiments. One of the earliest extensive series of experiments was made under the writer's direction in 1881, with a large number of models, the primary object being to determine what value there was in a few of the various twists which inventive ingenuity can give to a screw blade. The results led the experimenters to the conclusion that in free water such twists and curves are valueless as serving to augment efficiency. The experiments were then carried further with a view to determine quantitative moduli for the resistance of screws with different ratios of pitch to diameter, or "pitch ratios," and afterward with different ratios of surface to the area of the circle described by the tips of the blades, or "surface ratios." As these results have to some extent been analyzed and published, no further reference need be made to them now.

In 1886, Mr. R. E. Froude published in the Transactions of the Institution of Naval Architects the deductions drawn from an extensive series of trials made with four models of similar form and equal diameter, but having different pitch ratios. Mr. S. W. Barnaby has published some of the results of experiments made under the direction of Mr. J. I. Thornycroft; and in his paper read before the Institution of Civil Engineers in 1890 he has also put Mr. R. E. Froude's results into a shape more suitable for comparison with practice. Nor ought Mr. G. A. Calvert's carefully planned experiments to pass unnoticed, of which an account was given in the Transactions of the Institution of Naval Architects in 1887. These experiments were made on rectangular bodies with sections of propeller blade form, moved through the water at various velocities in straight lines, in directions oblique to their plane faces; and from their results an estimate was formed of the resistance of a screw.

One of the most important results deduced from experiments on model screws is that they appear to have practically equal efficiencies throughout a wide range both in pitch ratio and in surface ratio; so that great latitude is left to the designer in regard to the form of the propeller. Another important feature is that, although these experiments are not a direct guide to the selection of the most efficient propeller for a particular ship, they supply the means of analyzing the performances of screws fitted to vessels, and of thus indirectly determining what are likely to be the best dimensions of screw for a vessel of a class whose results are known. Thus a great advance has been made on the old method of trial upon the ship itself, which was the origin of almost every conceivable erroneous view respecting the screw propeller. The fact was lost sight of that any modification in form, dimensions, or proportions referred only to that particular combination of ship and propeller, or to one similar thereto; so something like chaos was the result. This, however, need not be the case much longer.

In regard to the materials used for propellers, steel has been largely adopted for both solid and loose-bladed screws; but unless protected in some way, the tips of the blades are apt to corrode rapidly and become unserviceable. One of the stronger kinds of bronze is often judiciously employed for the blades, in conjunction with a steel boss. Where the first extra expense can be afforded, bronze seems the preferable material; the castings are of a reliable character, and the metal does not rapidly corrode; the bronze blades can therefore with safety be made lighter than steel blades, which favors their springing and accommodating themselves more readily to the various speeds of the different parts of the wake. This might be expected to result in some slight increase of efficiency; of which, however, the writer has never had the opportunity of satisfactorily determining the exact extent. Instances can be brought forward where bronze blades have been substituted for steel or iron with markedly improved results; but in cases of this kind which the writer has had the opportunity of analyzing, the whole improvement might be accounted for by the modified proportions of the screw when in working condition. In other words, both experiment and practical working alike go to show that, although cast iron and steel blades as usually proportioned are sufficiently stiff to retain their form while at work, bronze blades, being made much lighter, are not; and the result is that the measured or set pitch is less than that which the blades assume while at work. Some facts relative to this subject have already been given in a recent paper by the author.

Twin Screws.—The great question of twin screw propulsion has been put to the test upon a large scale in the mercantile marine, or rather in what would usually be termed the passenger service. While engineers, however, are prepared to admit its advantages so far as greater security from total breakdown is concerned, there is by no means thorough agreement as to whether single or twin screws have the greater propulsive efficiency. What is required to form a sound judgment upon the whole question is a series of examples of twin and single screw vessels, each of which is known to be fitted with the most suitable propeller for the type of vessel and speed; and until this information is available, little can be said upon the subject with any certainty. So far the following large passenger steamers, particulars of which are given in table II., have been fitted with twin screws. It appears to be a current opinion that the twin screw arrangement necessitates a greater weight of machinery. This is not necessarily so, however; on the contrary, the opportunity is offered for reducing the weight of all that part of the machinery of which the weight relatively to power is inversely proportional to the revolutions for a given power. This can be reduced in the proportion of 1 to $\sqrt{2}$, that is 71 per cent. of its weight in the single screw engine; for since approximately the same total disk area is required in both cases with similar proportioned propellers, the twins will work at a greater speed of revolution than the single screw. From a commercial point of view there ought to be little disagreement as to the advantage of twin screws, so long as the loss of space incurred by the necessity for double tunnels is not important; and for the larger passenger vessels now built for ocean service the disadvantage should not be great. Besides their superiority in the matter of immunity from total breakdown, and in greatly diminished weight of machinery, they also offer the opportunity of reducing to some extent the cost of machinery. A slightly greater engine room staff is necessary; but this seems of little importance compared with the foregoing advantages.

TABLE II.—PASSENGER STEAMERS FITTED WITH TWIN SCREWS.

Vessels.	Length between perpendiculars.	Beam.	Cylinders, two sets in all cases. Diameters.	Stroke.	Boiler pressure per square inch.	Indicated horse-power.
	Feet.	Feet.	Inches.	Inches.	Lb.	
City of Paris. City of New York.	525	63¼	45, 71, 113	60	150	20,000
Teutonic. Majestic.	565	58	43, 68, 110	60	180	18,000
Normannia	500	57½	40, 67, 106	66	160	11,500
Columbia	463½	55½	41, 66, 101	66	160	12,500
Empress of India. Empress of Japan. Empress of China.	440	51	32, 51, 82	54	160	10,125
Orel	415	48	34, 54, 85	51	160	10,000

Weight of Machinery Relatively to Power.—It is interesting to compare the weight of machinery relatively to the power developed; for this comparison has sometimes been adopted as the standard of excellence in design, in respect of economy in the use of material. The principle, however, on which this has generally been done is open to some objections. It has been usual to compare the weight directly with the indicated horse-power, and to express the comparison in pounds per horse-power. So long as the machinery thus compared is for vessels of the same class and working at about the same speed of revolution, no great fault can be found; but as speed of revolution is a great factor in the development of power, and as it is often dependent on circumstances altogether external to the engine and concerning rather the speed of the ship, the engines fitted to high speed ships will thus generally appear to greater advantage than is their due. Leaving the condenser out of the question, the weight of an engine would be much better referred to cylinder capacity and working pressures, where these are materially different, than directly to the indicated power. The advantages of saving weight of machinery, so long as it can be done with efficiency, are well known and acknowledged. If weight is to be reduced, it must be done by care in design, not by reduction of strength, because safety and saving of repairs are much more important than the mere capability of carrying a few tons more of paying load. It must also be done with economy; but this is a matter which generally settles itself aright, as no shipowner will pay more for a saving in weight than will bring in a remunerative interest on his outlay. In his paper on the weight of machinery in the mercantile marine,* Mr. William Boyd discussed this question at some length, and proposed to attain the end of reducing the weight of machinery by the legitimate method of augmenting the speed of revolution and so developing the required power with smaller engines. This method, while promising, is limited by the efficiency of the screw, but may be adopted with advantage so long as the increase in speed of revolution involves no such change in the screw as to reduce its efficiency as a propeller. But when the point is reached beyond which a further change involves loss of propelling efficiency, it is time to stop; and the writer ventures to say that in many cargo vessels now at work the limit has been reached, while in many others it has certainly been passed.*

Economy of Fuel.—Coming to the highly important question of economy of fuel, the average consumption of coal per indicated horse-power is 1·522 lb. per hour. The average working pressure is 158·5 lb. per square inch. Comparing this working pressure with 77·4 lb. in 1881, a superior economy of 19 per cent. might be expected now, on account of the higher pressure, or taking the 1·828 lb. of coal per hour per indicated horse-power in 1881, the present performance under similar conditions should be 1·48 lb. per hour per indicated horse-power. It appears that the working pressures have been increased twice in the last ten years, and nearly three times in the last nineteen. The coal consumptions have been reduced 16·7 per cent. in the last ten years and 27·9 per cent. in the last nineteen. The revolutions per minute have increased in the ratios of 100, 105, 114; and the piston speeds as 100, 124, 140. Although it is quite possible that the further investigations of the Research Committee on Marine Engine Trials may show that the present actual consumption of coal per indicated horse-power is understated, yet it is hardly probable that the relative results will be affected thereby.

Dimensions.—In the matter of the power put into individual vessels, considerable strides have been made. In 1881, probably the greatest power which has been put into one vessel was in the case of the Arizona, whose machinery indicated about 6,300 horse-power. The following table gives an idea of the dimensions and power of the larger machinery in the later passenger vessels:

TABLE III.—DIMENSIONS AND POWER OF MACHINERY IN LATER PASSENGER VESSELS.

Year.	Name of vessel.	Diameters of cylinders.	Length of stroke.	Indicated horse-power.
		Inches.	Inches.	
1881	Alaska	68, 100, 100.	72	10,686
1881	City of Rome	46, 86; 46, 86; 46, 86.	72	11,800
1881	Servia	72, 100, 100.	78	10,300
1881	Livadia yacht.	60, 78, 78; 60, 78, 78; 60, 78, 78.	39	12,500
1883	Oregon	70, 104, 104.	72	13,300
1884	Umbria	71, 105, 105.	72	14,320
1884	Etruria			
1888	City of New York.	45, 71, 113;	60	20,000
1889	City of Paris	45, 71, 113.		about
1889	Majestic	43, 68, 110;	60	18,000
1889	Teutonic	43, 68, 110.		

In war vessels the increase has been equally marked. In 1881 the maximum power seems to have been in the Inflexible, namely, 8,485 indicated horse-power. The following will give an idea of the recent advance made: Howe (Admiral class), 11,600 indicated horse-power; Italia and Lepanto, 19,000 indicated horse-power; Re Umberto, 19,000 indicated horse-power; Blake and Blenheim (building), 18,000 indicated horse-power; Sardegna (building), 22,800 indicated horse-power. It is thus evident that there are vessels at work to-day having about three times the maximum power of any before 1881.

General Conclusions.—The progress made during the last ten years having been sketched out, however roughly, the general conclusions may be stated briefly as follows: First, the working pressure has been about doubled. Second, the increase of working pressure and other improvements have brought with them their equivalent in economy of coal, which is about 20 per cent. Third, marked progress has been made in the direction of dimension, more than twice the power having been put into individual vessels. Fourth, substantial advance has been made in the scientific principles of engineering. It only remains for the writer to thank the various friends who have so kindly furnished him with data for some of the tables which have been given; and to express the hope that the next ten years may be marked by such progress as has been witnessed in the past. But it must be remembered that, if future progress be equal in merit or ratio, it may well

* Transactions Northeast Coast Institution of Engineers and Shipbuilders, vol. 7, 1890-91, p. 179.

* Transactions Northeast Coast Institution of Engineers and Shipbuilders, vol. 6, 1889-90, p. 253.

be less in quantity, because advance becomes more difficult of achievement as perfection is more nearly approached.

THE LITTLE HOUSE.

By M. M.

ONE of the highest medical authorities is credited with the statement that "nine-tenths of the diseases that afflict humanity are caused by neglect to answer the calls of Nature."

This state of affairs is generally admitted, but is usually attributed to individual indolence. That, doubtless, has a great deal to do with it, but should not part of the blame be laid upon the often unpleasant environments, which make us shrink as from the performance of a painful duty?

In social life, unless from absolute necessity or charity, people of refined habits do not call on those whose surroundings shock their sense of decency; but when they go to pay the calls of Nature, they are often compelled to visit her in the meanest and most offensive of abodes; built for her by men's hands; for Nature herself makes no such mistakes in conducting her operations. She does not always surround herself with the pomp and pride of life, but she invariably hedges herself in with the thousand decencies and the pomp of privacy.

But what do we often do? We build what is sometimes aptly termed "an out-house," because it is placed so that the delicate minded among its frequenters may be made keenly alive to the fact that they can be plainly seen by every passer-by and by every idle neighbor on the lookout. This tiny building is seldom weatherproof. In consequence, keen cold winds from above, below, and all around find ready entrance, chill the uncovered person, frequently check the motions, and make the strong as well as the weak, the young as well as the old, very sorry indeed that they are so often uselessly obliged to answer the calls of Nature. It is true, the floor is sometimes carpeted with snow, but the feet feel that to be but cold comfort, though the door may enjoy rattling its broken hasp and creaking its loose hinges.

How often, too, are the nose and the eye offended by disregard of the Mosaic injunction, found in the twelfth, thirteenth, and fourteenth verses of the twenty-third chapter of Deuteronomy! Of course this injunction was addressed to a people who had been debased by slavery, but who were being trained to fit them for their high calling as the chosen of God; but is not some such sanitary regulation needed in these times, when a natural office is often made so offensive to us by its environments that it is difficult for us to believe that "God made man a little lower than the angels," or that the human body is the temple of the Holy Ghost?

Dwellers in the aristocratic regions of a well drained city, whose wealth enables them to surround themselves with all devices tending to a refined seclusion, may doubt all this, but sanitary inspectors who have made a round of domiciliary visits in the suburbs, or the older, neglected parts of a large city, or to any part of a country town or village, will readily affirm as to its general truth.

This unpardonable neglect of one of the minor decencies by the mass of the people seems to be caused partly by a feeling of false shame, and partly by an idea that it is expensive and troublesome to make any change that will improve their sanitary condition or dignify their daily lives.

The Rev. Henry Moule, of Fordington Vicarage, Dorsetshire, England, was one of the first to turn his attention to this matter. With the threefold object of improving the sanitary condition of his people, refining their habits, and enriching their gardens, he invented what he called the "dry earth closet."

"It is based on the power of clay and the decomposed organic matter found in the soil to absorb and retain all offensive odors and all fertilizing matters; and it consists, essentially, of a mechanical contrivance (attached to the ordinary seat) for measuring out and discharging into the vault or pan below a sufficient quantity of sifted dry earth to entirely cover the solid ordure and to absorb the urine.

"The discharge of earth is effected by an ordinary pull-up, similar to that used in the water closet, or (in the self-acting apparatus) by the rising of the seat when the weight of the person is removed.

"The vault or pan under the seat is so arranged that the accumulation can be removed at pleasure.

"From the moment when the earth is discharged and the evacuation covered, all offensive exhalation entirely ceases. Under certain circumstances there may be, at times, a slight odor as of guano mixed with earth, but this is so trifling and so local that a commode arranged on this plan may, without the least annoyance, be kept in use in any room."

The "dry earth closet" of the philanthropic clergyman was found to work well, and was acceptable to his parishioners. One reason why it was so was because dry earth was ready to hand, or could be easily procured in a country district where labor was cheap. But where labor was dear and dry earth scarce, those who had to pay for the carting of the earth and the removal of the deodorized increment found it both expensive and troublesome.

But a modification of this dry earth closet, the joint contrivance of an English church clergyman and his brother, "the doctor," residents of a Canadian country town, who had heard of Moule's invention, is a good substitute, and is within the reach of all. This will be briefly described.

The vault was dug as for an ordinary closet, about fifteen feet deep, and a rough wooden shell fitted in. About four feet below the surface of this wooden shell a stout wide ledge was firmly fastened all around. Upon this ledge a substantially made wooden box was placed, just as we place a well fitting tray into our trunks. About three feet of the back of the wooden shell was then taken out, leaving the back of the box exposed. From the center of the back of the box a square was cut out and a trap door fitted in and hasped down.

The tiny building, on which pains, paint, and inventive genius had not been spared to make it snug, comfortable, well lighted and well ventilated, was placed securely on this vault.

After stones had been embedded in the earth at the back of the vault, to keep it from falling upon the trap door, two or three heavy planks were laid across the hollow close to the closet. These were first covered with a barrowful of earth and then with a heap of brushwood.

Within the closet, in the left hand corner, a tall wooden box was placed, about two-thirds full of dry, well sifted wood ashes. The box also contained a small long-handled fire shovel. When about six inches of the ashes had been strewn into the vault the closet was ready for use. No; not quite; for squares of suitable paper had to be cut, looped together with twine, and hung within convenient reaching distance of the right hand; also a little to the left of this pad of paper, and above the range of sight when seated, a ten pound paper bag of the toughest texture had to be hung by a loop on a nail driven into the corner.

At first the rector thought that his guests would be "quick-witted enough to understand the arrangement," but when he found that the majority of them were, as the Scotch say, "dull in the uptak," he had to think of some plan to enforce his rules and regulations. As by-word-of-mouth instructions would have been rather embarrassing to both sides, he tacked up explicit written orders, which must have provoked many a smile. Above the bin of sifted ashes he nailed a card which instructed "Those who use this closet must strew two shovelfuls of ashes into the vault." Above the pad of clean paper he tacked the thrifty proverb: "Waste not, want not;" and above the paper bag he suspended a card bearing this warning: "All refuse paper must be put into this bag; not a scrap of clean or unclean paper must be thrown into the vault."

This had the desired effect. Some complacently united to humor their host's whim, as they called it, and others, immediately recognizing its utility and decency, took notes with a view to modifying their own closet arrangements.

Sarah, the maid of all work, caused a good deal of amusement in the family circle by writing her instructions in blue pencil on the front of the ash bin. These were: "Strew two shuffefuls of ashes into the volt, but don't spill two shuffefuls onto the floor. By order of the Gurl who has to sweap up." This order was emphatically approved of by those fastidious ones who didn't have to "sweep up."

This closet opened off the woodshed, and besides being snugly weatherproof in itself, was sheltered on one side by the shed and on another by a high board fence. The other two sides were screened from observation by lattice work, outside of which evergreens were planted to give added seclusion and shade. A ventilator in the roof and two sunny little windows, screened at will from within by tiny Venetian shutters, gave ample light and currents of fresh air. For winter use, the rector's wife and daughters made "hooked" mats for floor and for foot support. These were hung up every night in the shed to air and put back first thing in the morning. For the greater protection and comfort of invalids, an old-fashioned foot warmer, with a handle like a basket, was always at hand ready to be filled with live coals and carried out.

The little place was always kept as exquisitely clean as the dainty, old-fashioned drawing room, and so vigilant was the overseeing care bestowed on every detail, that the most delicate and acute sense of smell could not detect the slightest abiding unpleasant odor. The paper bag was frequently changed, and every night the accumulated contents were burned; out of doors in the summer, and in the kitchen stove—after a strong draught had been secured—in the winter.

At stated times the deodorized mass of solid increment—in which there was not or ought not to have been any refuse paper to add useless bulk—was spaded, through the trap door, out of the box in the upper part of the vault, into a wheelbarrow, thrown upon the garden soil, and thoroughly incorporated with it. In this cleansing out process there was little to offend, so well had the ashes done their concealing deodorizing work.

In using this modified form of Moule's invention, it is not necessary to dig a deep vault. The rector, given to forecasting, thought that some day his property might be bought by those who preferred the old style, but his brother, the doctor, not troubling about what might be, simply fitted his well made, four feet deep box, with its trap door, into a smoothly dug hole that exactly held it, and set the closet over it. In all other respects it was a model of his brother's.

This last is within the reach of all, even those who live in other people's houses; for, when they find themselves in possession of an unspeakably foul closet, they can cover up the old vault and set the well cleaned, repaired, fumigated closet upon a vault fashioned after the doctor's plan. A stout drygoods box, which can be bought for a trifle, answers well for this purpose, after a little "tinkering" to form a trap door.

Of course, dry earth is by far the best deodorizer and absorbent, but when it cannot be easily and cheaply procured, well sifted wood or coal ashes—wood preferred—is a good substitute. The ashes must be kept dry. If they are not, they lose their absorbing, deodorizing powers. They must also be well sifted. If they are not, the cinders add a useless and very heavy bulk to the increment.

An ash sifter can be made by knocking the bottom out of a shallow box, studding the edge all round with tacks, and using them to cross and recross with odd lengths of stovepipe wire to form a sieve.—*The Sanitarian.*

THE HYGIENIC TREATMENT OF OBESITY.*

By DR. PAUL CHERON.

IN order to properly regulate the regimen of the obese, it is first necessary to determine the source of the superfluous adipose of the organism, since either the albuminoids or the hydrocarbons may furnish fat.

Alimentary fat becomes fixed in the tissues, as has been proved by Lebede, who fed dogs, emaciated by long fast, with meat wholly deprived of fat, and substituted for the latter linseed oil, when he was able to recover the oil in each instance from the animal; parallel experiments with mutton fat, *in lieu* of oil, afforded like results.

Hoffman also deprived dogs of fat for a month, causing them to lose as high as twenty-two pounds weight, then began nourishing with bacon fat with but little lean; the quantity of fat formed in five days, in the dog that lost twenty-two pounds, was more than three pounds, which could have been derived only from the bacon fat.

It has been stated, however, that alimentary fat seems to preserve from destruction the fat of the organism which arises from other sources. Be this as it may, it is a fact that the pre-existence of fat furthers the accumulation of more adipose; or in other words, fat induces fattening!

That adipose may be formed through the transformation of albuminous matters (meat) is an extremely important corollary, one established beyond cavil by Pettinkofer and Voit, in an indirect way, by first estimating the nitrogen and carbon ingested, and second the amount eliminated. Giving a dog meat that was wholly deprived of fat, they found it impossible to recover more than a portion of the contained carbon; hence some must necessarily have been utilized in the organism, and this would be possible only by the transformation of the carbon into fat! It goes without saying, however, that the amount of adipose thus deposited is meager.

Other facts also plead in favor of the transformation of a portion of albumen into fat within the economy, notably the changing of a portion of dead organism into what is known as "cadaveric fat," and the very rapid fatty degeneration of organs that supervenes upon certain forms of poisoning, as by phosphorus.

The carbohydrates, or more properly speaking hydrocarbons, are regarded by all physiologists as specially capable of producing fat, and numerous alimentary experiments have been undertaken to prove this point. Chaniewski, Meissl, and Munk obtained results that evidenced, apparently, sugar and starch provide more fat than do the albuminoids. Voit, however, disapproves this, maintaining the greater part of the hydrocarbons is burned (furnishes fuel for the immediate evolution of force), and that fat cannot be stored up unless a due proportion of albuminoids is also administered. He believes the hydrocarbons exert a direct influence only; being more oxidizable than fats, they guard the latter from oxidation. This protective role of the hydrocarbons applies also to the albuminoids.

We may believe, then, that the three great classes of aliment yield fat, in some degree; that alimentary fat may be fixed in the tissues; and that hydrocarbons favor the deposition of adipose either directly or indirectly.

It is well understood that fat may disappear with great rapidity under certain conditions; many maladies are accompanied by speedy emaciation; therefore, as fat never passes into the secretions, at least not in appreciable quantities, it probably undergoes transformation, perhaps by oxidation or a form of fermentation, the final results of which are, directly or indirectly, water and cadaveric acid. It is certain the process of oxidation favors the destruction of adipose, and that everything which inhibits such destruction tends to fat accumulation.

Since the earliest period of history, there seems to have been an anxiety to secure some regimen of general application that would reduce or combat obesity. Thus Hippocrates says:

Fat people, and all those who would become lean, should perform laborious tasks while fasting, and eat while still breathless from fatigue, without rest, and after having drunk diluted wine not very cold. Their meats should be prepared with sesamum, with sweets, and other similar substances, and these dishes should be free from fat.

In this manner one will be satiated through eating less.

But, besides, one should take only one meal; take no bath; sleep on a hard bed; and walk as much as may be.

How much has medical science gained in this direction during the interval of more than two thousand years? Let us see:

First among moderns to seek to establish on a scientific basis a regimen for the obese, was Dancel, who forbade fats, starchy foods, etc., prescribed soups and aqueous aliment, and reduced the quantity of beverage to the lowest possible limit; at the same time he employed frequent and profuse purgation.

This regimen, which permits, at most, but seven to twelve ounces of fluid at each repast, is somewhat difficult to follow, though it may be obtained, gradually, with ease. Dr. Constantine Paul records a case in which this regimen, gradually induced, and followed for ten years, rewarded the patient with "moderate flesh and most excellent health."

In Great Britain, a mode of treatment instituted in one Banting, by Dr. Harvey, whereby the former was decreased in weight forty pounds, has obtained somewhat wide celebrity; and what is more remarkable, it is known as "Bantingism," taking its name from the patient instead of the physician who originated it. The dietary is as follows:

Breakfast.—Five to six ounces of lean meat, broiled fish, or smoked bacon—veal and pork interdicted; a cup of tea or coffee without milk or sugar; one ounce of toast or dry biscuit (crackers).

Dinner.—Five or six ounces of lean meat or fish—excluding eel, salmon, and herring; a small quantity of vegetables, but no potatoes, parsnips, carrots, beets, peas, or beans; one ounce of toast, fruit, or fowl; two glasses of red wine—beer, champagne, and port forbidden.

Tea.—Two or three ounces of fruit; one kind of pastry; one cup of tea.

Supper.—Three or four ounces of lean beef or fish; one or two glasses of red wine.

At bed-time.—Grog without sugar (whisky and water, or rum and water), and one or two glasses of sherry or Bordeaux.

"Bantingism," to be effective, must be most closely followed, when, unfortunately also, it proves extremely debilitating; it is suitable only for sturdy, hard riding gluttons of the Squire Western type. The patient rapidly loses strength as well as flesh, and speedily acquires an unconquerable repugnance to the dietary. Further, from a strictly physiological point of view, the quantity of meat is greatly in excess, while with the cessation of the regimen, the fat quickly reappears.

Next Ebstein formulated a dietary that is certainly much better tolerated than that of Harvey and Bant-

* Translated by Mr. Jos. Helfman, Detroit, Mich.

ing, and yields as good, or even better, results. He allows patients to take a definite quantity—two to two and a half ounces—of fat daily, in the form of bacon or butter, which, theoretically at least, offers several advantages: It diminishes the sensations of hunger and thirst, and plays a special role with respect to the albuminoids; the latter may thus be assimilated by the economy without being resolved into fat, and thus the adipose of the organism at this period is drawn upon without subsequent renewal. The following is the outline:

Breakfast.—At 6 a. m. in summer; 7:30 in winter:—Eight ounces of black tea without either milk or sugar; two ounces of white bread or toast, with a copious layer of butter.

Dinner.—2 p. m.:—A modicum of beef marrow soup; four ounces of meat, preferably of fatty character; moderate quantity of vegetable, especially the legumines, but no potatoes or anything containing starch; raw fruits in season, and cooked fruits (stewed, without sugar); two or three glasses of light wine as a beverage, and after eating, a cup of black tea without sugar.

Supper.—7:30 p. m.:—An egg, bit of fat roast, ham, or bacon; a slice of white bread well buttered; a large cup of black tea without milk or sugar; from time to time, cheese and fresh fruits.

Germain See suggests as a modification of this regimen, the abundant use of beverage, the addition of gelatins, and at times small doses of potassium iodide; in twenty cases he claims constant and relatively prompt results.

Whatever may be urged for Ebstein's system—and it has afforded most excellent results to Unna and to Lube, as well as its author—it certainly exposes the patient to the terrors of dyspepsia, when the routine must needs be interrupted or modified; hence it is not always to be depended upon. As between dyspepsia and obesity, there are few, I fancy, who would not prefer the latter.

Another "system" that has acquired no little celebrity, and which has for its aim the reduction as far as possible of alimentary hydrocarbons while permitting a certain proportion of fat, is that of Denneth, which necessarily follows somewhat closely the lines laid down by Ebstein.

Oertels' treatment, somewhat widely known, and not without due measure of fame, is based upon a series of measures having as object the withdrawal from both circulation and the economy at large, as much of the fluids as possible. It is especially adapted for the relief of those obese who are suffering fatty degeneration of the heart. The *menu* is as follows:

Breakfast.—Four to five ounces of tea or coffee with a little milk; two to two and a half ounces bread.

Dinner.—Three or four ounces of roast or boiled meat, or moderately fat food; fish, slightly fat; salad and vegetables at pleasure; one and a half ounces of bread (in certain cases as much as three ounces of farinaceous food may be permitted); three to six ounces of fruit; at times a little pastry for dessert.—In summer, if fruit is not obtainable, six to eight ounces of light wine may be allowed.

Tea.—A cupful (four to five ounces) of tea or coffee, with a trifle of milk, as at breakfast; one and three-fourths ounces of bread; and exceptionally (and at most) six ounces of water.

Supper.—One to two soft boiled eggs; four or five ounces of meat; one and three fourths ounces of bread; a trifle of cheese, salad, or fruit; six to eight ounces of light wine diluted with an eighth volume of water. The quantity of beverage may be slightly augmented at each meal if necessary, especially if there is no morbid heart trouble.

Schwenninger (Bismarck's physician), who opened a large sanitarium near Berlin a few years since for the treatment of the obese, employs Oertel's treatment, modified in that an abundance of beverage is permitted, provided it is not indulged in at meals; it is forbidden until two hours after eating.

Both Oertel's and Schwenninger's methods have procured grave dyspepsias, and fatal albuminurias as well, according to Meyer and Rosenfield. It has been charged the allowance of beverage upon which Schwenninger lays so much stress in the treatment at his sanitarium has a pecuniary basis, in other words a commission upon the sale of wines.*

Thus, it will be observed that while some forbid beverage, others rather insist upon its employment in greater or less quantities. Under such circumstances, it would seem but rational, before undertaking to relieve obesity, to establish its exact nature, and also the role taken by fluids in the phenomena of nutrition.

Physiologists generally admit water facilitates nutritive exchanges, which is explained by the elimination of a large quantity of urine; the experiments of Genth and Robin in this direction appear conclusive.

Bischoff, Voit, and Hermann have shown that water increases, not alone the elimination of urine, but also of sodium chloride, phosphoric acid, etc. Grigoriantz observed augmentation of disintegration when the quantity of beverage exceeded forty-six to eighty ounces ("1,400 to 2,400 cubic centimeters") per diem. Oppenheim, Fraenkel, and Debove, while believing water has but little influence upon the exchanges, admit it certainly need not diminish the latter; and Debove and Flament, after administering water in quantities varying from two to eight pints per diem, concluded that urine was diminished below the former figure, while above the latter it increased somewhat, being dependent upon the amount ingested. It was on the strength of the foregoing that Lallemand declared water to have no influence upon the exchanges.

The results claimed by Oppenheim, Debove, *et al.* were immediately challenged—and it is now generally admitted, not without some justice—by Germain See. It seems certain, to say the least, that water taken during the repast does tend to augment the quantity and facilitate the elimination of urine. Abundance of beverage, moreover, presents other advantages, in that it facilitates digestion by reason of its diluent action, a fact well worth bearing in mind when treating the obese who are possessed of gouty diathesis, and whose kidneys are accordingly encumbered with uric and oxalic acids. The foregoing presents the ground upon which Germain See permits an abundance of beverage; but he also expresses strong reservation as regards beer and alcohol, either of which (more especially the former) tends to the production of adipose. In his opinion, the only beverage of the alcoholic class that is at all permissible, and then only for cases suffering from fatty heart, is a little *liqueur* or diluted wine. Coffee and tea he commends highly, and recommends the ingestion of large quantities at high temperature, both during the repasts and their intervals. Coffee in large doses is undoubtedly a means of de-nutrition, and so, too, in no less extent, is tea; both act vigorously owing to the contained alkaloids, though, to be sure, they sometimes, at first, tend to insomnia and palpitation, to which no attention need be paid, however. The treatment outlined by See is:

1. A physiological regimen comprising four to five ounces of nitrogenous principles as derived from eight to ten ounces animal muscle and albuminates; three to six ounces of fat; eight to ten ounces of hydrocarbons as yielded by ten to twelve ounces of sugar or starch food.

These proportions to be modified in such manner that the musculo-albuminates shall not sensibly exceed the normal ratio, for meat in excess itself furnishes fat during transformation. The fatty substances of easy digestion may, without inconvenience, be utilized in doses of two to three ounces. The hydrocarbons should be reduced to a minimum. As for the herbaceous elements, they contain nothing nutritive.

2. Beverage, far from being suppressed, should be augmented, in order to facilitate stomachal digestion and promote general nutrition, though alcoholic liquids must be inhibited; likewise mineral waters, except, perhaps, for occasional use. Both should be replaced by infusions of coffee or tea, taken as hot as can be drank.

Henrich Kisch insists that any method which promises rapid and marked decrease of adipose must, *per se*, be objectionable, even if not positively injurious, since it tends to provoke general troubles of nutrition. He suggests that first the fats and hydrocarbons be reduced as little as possible; that a moderate mixed regimen is required, containing a preponderance of albumen, small quantities of hydrocarbons and gelatinous matters, with but very little fat. Certain fatty meats, however, should be generally interdicted, such as pork sausage, smoked beef tongue, goose breast, smoked ham, fat salmon, and herring in any form. Eggs, however, may be partaken of in moderation, giving preference to the albumen over the yelk. Farinaceous foods, in the main, should be rejected, even bread being allowed only in small quantities, and then preferably in the form of toast. Cheese likewise contains too much fat; and mushrooms are so rich in hydrocarbons that they should be rejected. Condiments, water, vegetable acids (vinegars excepted) may be permitted; especially pernicious is vinegar where there is any tendency to gout or gravel. All fatty beverages—*bouillon*, unskimmed milk, chocolate, or cacao—and all alcoholics, are hurtful; breakfast tea is undoubtedly the best beverage, but, after a little, is advantageously replaced by light white wine diluted with water.

Kisch believes in a free and abundant use of water by the obese, especially where there is a tendency to plethora, since this fluid facilitates oxidation as the result of absorption; thus he advocates the inhibition of large quantities of cold water by all, save those presenting evidence of cardiac insufficiency. In short, his regimen is based upon the administration of a large quantity of albumen, like that of Harvey-Banting.

E. Munk recommends an almost identical dietary, save that he prefers great moderation in fluids employed as beverage.

M. Robin has sought to harmonize the opposing views regarding fluids, and therefore declares obesity arises from two distinct sources: 1. Augmentation of assimilation. 2. Reduced disassimilation. In the former, he insists water must be interdicted, while in the latter it may be allowed *ad libitum*.

Again, in order to recognize the exact variety of obesity, he divides his patients into three classes, each recognizable by the volume of urea excreted. In the first there is an increase above normal; in the second the volume of urea is stationary; in the third decreased, increased, or stationary.

When the urea is stationary, which is most frequently the case, it is necessary to calculate the coefficient of oxidation; that is, the relation existing between the solid matters of the urine and the urea. The elevation of the coefficient is *prima facie* evidence the obesity is due to excess of assimilation, while depression of the coefficient indicates default of assimilation. In the first case, water and liquids must be denied as far as possible, the same as if there was no augmentation of urea; in the second, the same as if there was diminution of urea, the patients may be permitted to imbibe fluids at pleasure.

For the obese from default of disassimilation, Robin recommends a regimen of green vegetables and bread chiefly—the latter in small quantities, however, and fluids as may be desired. By this means, on one occasion, he was able in the course of one month to diminish the weight of a female patient by twelve and a half pounds, her measurement around the waist at the same time decreasing 5·2 inches and across the stomach 4·8 inches.

M. De St. Germain achieved good results by combining judicious exercise with moderate alimentation, excluding wine and bread.

M. Dujardin Beaumetz, who professes to have given most close and careful study and attention to regimen for the obese, outlines the following, provided there is no evidence of fatty degeneration of heart.

Breakfast (at 8 a. m.)—Three-fourths of an ounce of bread "*en flute*"—that is abounding with crust; one and a half ounces of cold meat, ham or beef, six ounces weak black tea, *sans* sugar.

Lunch (at 1 p. m.)—An ounce and a half to two ounces of bread, or a *ragout*, or two eggs; three ounces green vegetables; one-half ounce of cheese; fruits at discretion.

Dinner (at 7 p. m.)—An ounce and a half to two ounces of bread; three to four ounces of meat, or *ragout;* ditto of green vegetables, salad, half an ounce of cheese, fruit *ad libitum*.

At meal times the patient may take only a "glass and a half" of liquid—approximately ten ounces—though a greater amount may be permitted if he abstains during the intervals.

Special alimentary regimen, however, does not constitute the sole treatment of obesity. Concurrently must be employed a number of practical adjuvants which are oftentimes of the utmost assistance. For one thing, exercise is indispensable; all authorities agree on this point. The exercise taken in the gymnasium is one of the best, notably the "wall exercise," which is more particularly suited to those afflicted with pendulous and protuberant abdomens as the result of feebleness of the hypogastric muscles, to accumulation of fat under the skin and in the omentum, and to dilation of the stomach and intestines. In the "wall exercise," the patient stands erect against an absolutely straight and plumb wall, lifts his hands (carrying a weight) straight over the head, and causes them to describe a semicircle forward. Zantz particularly insists upon arm and leg exercise for the obese, especially the former, since with the same amount of effort a larger amount of oxygen is consumed than is possible by the latter.

However, of whatever character, the exercise should be continued to the point of fatigue or dyspnœa—three thousand movements daily, gradually increased to twenty-five thousand, if the system can bear it; and under such conditions, not only is there consumption of hydrocarbons, but there is provided a veritable greed for air that augments waste. The experiments of Oertel indicate that loss of weight due to fatiguing exercise arises more particularly from dehydration, which is made good by absorption of the fluids employed as beverage; the fluids are claimed by Germain See to act as accelerants of oxidation.

During exercise there is obviously more abundant absorption of oxygen, and consequently greater elimination of carbonic acid, and as a consequence (as shown by researches of Voit), the reserve fat of the economy is attacked and diminished; in intense labor there is an average hourly consumption of about 8·2 per cent. of fat. Further physical activity is useful in exercising the voluntary muscles, and thus opposing the invasion by interstitial fat of the muscle fibrils. Extreme exercise also, to a certain degree, exerts a favorable influence on the cardiac muscle, augmenting both its nutrition and its capacity for labor. With the anæmic obese, however, it is necessary to be most circumspect in prescribing forced exercise; also with the elderly obese possessed of enfeebled or fatty heart.

Hydrotherapy, especially in the form of cold douches, particularly when combined with massage, is often of considerable value in relieving obesity; the method of Harmman, of St. Germain, which has in many instances induced rapid loss of adipose, is of this class. Tepid saline baths and vapor baths have many advocates, and may afford material aid when the heart and circulation do not inhibit their employment. Hot baths elevate the temperature of the body and increase the organic exchanges, hence, as Bert and Reynard have pointed out, tend to the elimination of oxygen and carbonic acid; but when employed, the patient should be introduced while the temperature is below 130° F., when it may be gradually raised in the course of thirty or forty minutes to 140° F.

It has already been intimated, the chief feature of the treatment of obesity is acceleration of the exchanges; and this is in the main true, though it must also be borne in mind that, while there are obese who excrete little urea and have a depressed central nervous temperature, many may be azoturic, and besides eliminate phosphates in excess, when an oxidating treatment will not only fail, but prove positively injurious.

The bile throws out fat, therefore, to accelerate nutritive oxidations, the liver and nervous system must be acted upon, *i. e.*, stimulated. Everything that tends to diminish the activity of the former, or depress the latter, must be avoided. Hence intellectual labor should be encouraged, or in lieu thereof, travel advised. Exercise should be taken chiefly while fasting; the limits of sleep confined to strict necessity, and *siestas* after meals and during the day strictly forbidden; the skin stimulated by hydro-therapeutic measures, including massage under cold affusions, during warm salt baths, etc.

To increase the activity of the liver, salicylate of soda may often be advantageously administered for its cholagogue effect; or resort may be had to saline purgatives such as are afforded by the springs of Marienbad, Kissengen, Homburg, Carlsbad, Brides, Hunyadi, or Chatel-Guyon; and it is somewhat remarkable that while undergoing a course of these waters, there is often no appreciable change in weight or obesity, though the decrease becomes most marked almost immediately upon cessation of treatment.

Everything tending to increased or fuller respiration is to be encouraged, for the fats are thus supplied with oxygen, hastening their disintegration and consumption.

Direct medicinal treatment presents no very wide scope. Bouchard imagines lime water may be useful by accelerating nutrition, but this is problematical, since fat in emulsion or in droplets does not burn. Nevertheless, alkalies in general, alkaline carbonates, liquor potassa, soaps, etc., aid in rendering fat more soluble, and consequently more susceptible to attack. The alkaline waters, however, are much less active in obesity than the saline mineral waters, unless, as sometimes happens, there is a complication of diabetes and obesity.

Purgatives are always more or less useful, and often required to be renewed with all the regularity of habit. Then too, the iodides, especially iodide of sodium or potassium, as recommended by M. Germain See, frequently prove of excellent service by aiding elimination and facilitating the mutations.

According to Kisch, the cold mineral waters containing an abundance of sulphate of soda, like Hunyadi and Marienbad, are to be preferred to the hot mineral waters, such as Carlsbad, because of their lesser irritant action on the vascular system, and because they strongly excite diuresis through their low temperature and contained carbonic acid; Carlsbad deserves preference only when obesity is combined with uric acid calculi, or with diabetes. For very anæmic persons, however, the weak alkaline and saline waters should be selected; or they should confine themselves to chalybeate waters containing an excess of sulphate of soda. Water containing sulphate of soda is also indicated as a beverage where there are troubles of the circulatory apparatus; it is contraindicated only in accentuated arterio-sclerosis.

As a matter of fact, I find the suggestion of M.

* The sanitarium is owned by a stock company, Schwenninger being merely Medical Director.—ED.

Dujardin-Beaumetz, that the obese should be divided into two groups, a most practical one, for some are strong and vigorous—great eaters, perhaps even gluttons—while others, on the contrary, are feeble and debilitated, with flesh soft and flaccid; and upon the former may be imposed all the rigors of the reducing system, while the latter must be dealt with more carefully.

In general, it must be noted, the regimen prescribed for the obese is insufficient, as the following table prepared by M. C. Paul abundantly proves:

Author.	Albuminous Matters.	Fatty Matters.	Hydro-carbons.
Voit	118	40	150
Harvey-Banting	170	10	80
Ebstein	100	85	50
Oertel	155–179	25–41	70–110
Kisch (plethoric)	160	10	80
" (anæmic)	200	12	100
Normal ration	124	55	455

There is, therefore, as Dujardin-Beaumetz asserts, autophagia in the obese, and all these varieties of treatment have but one end, viz.: Reduction of the daily ration. But the quantity of nourishment should not be too greatly curtailed, for, manifestly, if the fat disappears the more surely, the muscles (rich in albumen) undergo too rapid modification. It is progressive action that should always be sought.

The quantity of aliment may be reduced either by imposing an always uniform regimen, which soon begets anorexia and disgust, or by withholding from the food a considerable quantity of fat, or, finally, by forbidding beverage during meals. Emaciation is obtained readily enough in either way, and demands only the constant exercise of will power on the part of the patient; but unhappily, severe regimen cannot always be prescribed. When the obese patient has passed the age of forty; when the heart suffers from degeneration; or when the heart is anæmic—in all, rigorous treatment will serve to still further enfeeble the central organ of circulation, and tend to precipitate accidents that, by all means, are to be avoided. In such cases, by *not* treating the obesity, the days of the patient will be prolonged. In degeneration of the heart, however, the method of Ebstein may be tried; and when there is renal calculi and gouty diathesis, that of Germain See may prove satisfactory.

Paris, France.

STILT WALKING.

Sylvain Dornon, the stilt walker of Landes, started from Paris on the 12th of last March for Moscow, and reached the end of his journey at the end of a fifty-eight days' walk. This long journey upon stilts constitutes a genuine curiosity, not only to the Russians, to whom this sort of locomotion is unknown, but also to many Frenchmen.

Walking on stilts, in fact, which was common twenty years ago in certain parts of France, is gradually tending to become a thing of the past. In the wastes of Gascony it was formerly a means of locomotion adapted to the nature of the country. The waste lands were then great level plains covered with stunted bushes and dry heath. Moreover, on account of the permeability of the subsoil, all the declivities were transformed into marshes after the slightest fall of rain.

There were no roads of any kind, and the population, relying upon sheep raising for a living, was much scattered. It was evidently in order to be able to move around under these very peculiar conditions that the shepherds devised and adopted stilts. The stilts of Landes are called, in the language of the country, *tchangues*, which signifies "big legs," and those who use them are called *tchanguès*. The stilts are pieces of wood about five feet in length, provided with a shoulder and strap to support the foot. The upper part of the wood is flattened and rests against the leg, where it is held by a strong strap. The lower part, that which rests upon the earth, is enlarged and is sometimes strengthened with a sheep's bone. The Landese shepherd is provided with a staff which he uses for numerous purposes, such as a point of support for getting on to the stilts and as a crook for directing his flocks. Again, being provided with a board, the staff constitutes a comfortable seat adapted to the height of the stilts. Resting in this manner, the shepherd seems to be upon a gigantic tripod. When he stops he knits or he spins with the distaff thrust in his girdle. His usual costume consists of a sort of jacket without sleeves, made of sheep skin, of canvas gaiters, and of a drugget cloak. His head gear consists of a beret or a large hat. This accouterment was formerly completed by a gun to defend the flock against wolves, and a stove for preparing meals.

The aspect of the Landeses is doubtless most picturesque, but their poverty is extreme. They are generally spare and sickly, they are poorly fed and are preyed upon by fever. Mounted on their stilts, the shepherds of Landes drive their flocks across the wastes, going through bushes, brush and pools of water, and traversing marshes with safety, without having to seek roads or beaten footpaths. Moreover, this elevation permits them to easily watch their sheep, which are often scattered over a wide surface. In the morning the shepherd, in order to get on his stilts, mounts by a ladder or seats himself upon the sill of a window, or else climbs upon the mantel of a large chimney. Even in a flat country, being seated upon the ground, and having fixed his stilts, he easily rises with the aid of his staff. To persons accustomed to walking on foot, it is evident that locomotion upon stilts would be somewhat appalling.

One may judge by what results from the fall of a pedestrian what danger may result from a fall from a pair of stilts. But the shepherds of Landes, accustomed from their childhood to this sort of exercise, acquire an extraordinary freedom and skill therein. The *tchanguè* knows very well how to preserve his equilibrium; he walks with great strides, stands upright, runs with agility, or executes a few feats of true acrobatism, such as picking up a pebble from the ground, plucking a flower, simulating a fall and quickly rising, running on one foot, etc.

The speed that the stilt walkers attain is easily explained. Although the angle of the legs at every step is less than that of ordinary walking with the feet on the ground, the sides prolonged by the stilts are five or six feet apart at the base. It will be seen that with steps of such a length, distances must be rapidly covered.

When, in 1808, the Empress Josephine went to Bayonne to rejoin Napoleon I. who resided there by reason of the affairs of Spain, the municipality sent an escort of young Landese stilt walkers to meet her. On the return, these followed the carriages with the greatest facility, although the horses went at a full trot.

During the stay of the empress, the shepherds, mounted upon their stilts, much amused the ladies of the court, who took delight in making them race, or in throwing money upon the ground and seeing several of them go for it at once, the result being a scramble and a skillful and cunning onset, often accompanied with falls.

Up to recent years scarcely any merry-makings occurred in the villages of Gascony that were not accompanied with stilt races. The prizes usually consisted of a gun, a sheep, a cock, etc. The young people vied with each other in speed and agility, and plucky young girls often took part in the contests.

Some of the municipalities of the environs of Bayonne and Biarritz still organize stilt races, at the period of the influx of travelers; but the latter claim that the stiltsmen thus presented are not genuine Landese shepherds, but simple supernumeraries recruited at hazard, and in most cases from among strolling acrobats. The stilt walkers of Landes not only attain a great speed, but are capable of traveling long distances without appreciable fatigue.

Formerly, on the market days at Bayonne and Bordeaux, long files of peasants were seen coming in on stilts, and, although they were loaded with bags and baskets, they came from the villages situated at 10, 15, or 20 leagues distance. To-day the sight of a stilt walker is a curiosity almost as great at Bordeaux as at Paris. The peasant of Landes now comes to the city in a wagon or even by railway.—*La Nature.*

SYLVAIN DORNON, THE STILT WALKER OF LANDES.

REMAINS OF A ROMAN VILLA IN ENGLAND.

A correspondent of the *Lincolnshire Chronicle* writes: For some weeks past, remains of a Roman villa have been exposed to view by Mr. Ramsden's miners in the Greetwell Fields. From the extent of the tessellated pavements laid bare there is hardly any doubt that in the Greetwell Fields, in centuries long gone by, there stood a Roman mansion, which for magnitude was perhaps unrivaled in England. Six years ago I drew attention to it. The digging for iron ore soon after this was brought to a standstill by the company, which at the time was working the mines, ceasing their operations. Then the property came into other hands, and since then more extensive basement floors of the villa have from time to time been laid bare, and from tentative explorations which have been just made, still more floors remain to be uncovered which may be of a most interesting and instructive character. What a pity it is that the inhabitants of Lincoln have not made an effort to preserve these precious relics of the grandeur of the Roman occupation, an occupation to which England owes so much. From the Romans the people of this country inherit the sturdy self-reliance and perseverance in action which have helped to make England what it is, and from the Romans too, in a great degree, does England also inherit her colonizing instincts, which impel her people to cover the waste places of the world with colonies. If the Roman remains which have been so abundantly discovered of late years in Lincoln and its vicinity had been collected and laid out for exhibition, they would have formed a most interesting collection of antiquities worthy of the town, and well worth showing to visitors who now annually make Lincoln a visitation.

Although these relics of a remote age are being dug up and are being destroyed, it is not the fault of Mr. Ramsden, for he not only preserved them as long as he conveniently could, but he also had the soil removed from over them, and had them thoroughly washed, in order that people might have an opportunity of seeing their extent and beauty. One of these patches of pavement extended 48 yards northward from what might be called the main building, which had previously been broken up. This strip was 13 ft. in breadth, and down its center ran an intricate pattern worked in blue tesseræ. The pattern is much used in these days in fabrics and works of art, and is, I think, called the Grecian or Roman key pattern. On each side of this ran alternately broad ribbons of white and narrower ribbons of red tesseræ. There is also another strip of pavement to the south of the preceding patch, which has been laid bare to the extent of 27 yards. This patch is about 10 ft. in breadth, and its western portion is cut up in neat patterns, which show that they formed the floors of rooms. From the eastern extremity of these floors evidently another long strip of 48 or 50 yards still remains to be uncovered. Doubtless there are other remains beneath the ground which will be laid bare as the work of mining goes on. All these floors were not deeper than from 18 to 30 inches below the surface of the soil. The bones of animals and other relics have been found in the covering soil and have been turned up by the miners from time to time. The pavement is all worked out with cubes, varying in size from an inch and a half to two inches square, each piece being placed in position with most careful exactness. The strip which extends 48 yards and is 13 ft. wide runs due north and south. There is a second patch, running east and west, and this is 27 ft. long by 10 ft. wide, while a third is 27 ft. long by 11 ft. wide, this also running in a northern direction. To the north of this latter piece, and separated only by about two feet (about the width of a wall, which very possibly was the original division), there is a strip of tesseræ 16 ft. wide, which had been laid bare 40 yards. It was thought probable that at the end of the last named strip still another patch would be found. Mr. Ramsden, the manager of the Ironstone Works, is keeping a plan of the whole of the pavement, which he is coloring in exact imitation of the original work. This, when completed, will be most interesting, and he will be quite willing to show it to any one desirous of inspecting the same. Many persons have paid a visit to the spot where the discoveries have been made, and surprise is invariably expressed at the magnitude and beautiful symmetry of the work.

Several interesting fragments of Roman work have been brought to light in the course of excavations that are being made for building purposes at Twyford, near Winchester. About a month ago, a paved way, composed entirely of small red tiles, six feet in width and extending probably a considerable distance (a length of 14 ft. was uncovered), was found while digging on the site for flints. The more recent excavations are 20 ft. west of this passage, and there is now to be seen, in a very perfect state of preservation, an oven or kiln with three openings. Five yards away from this is a chamber about eight feet square, paved with tiles, and the sides coated with a reddish plaster. On one side is a ledge 15 in. from the ground, extending the whole length of the chamber; on the floor is a sunk channel with an opening at the end for the water to escape. This chamber evidently represents the bath. Portions of the dividing walls of the different chambers have

also been discovered, together with various bones, teeth, horns and ornaments, but very few coins. It is probable that an alteration in the plans of the house which was about to be built on the spot will be made so as to preserve all the more interesting features of these remains in the basement. These discoveries were made at a depth of only two or three feet from the surface of the ground, and are within about a quarter of a mile of other Roman remains which were similarly brought to light a few months ago.

[Continued from SUPPLEMENT, No. 820, page 13110.]

GUM ARABIC AND ITS MODERN SUBSTITUTES.*

By Dr. S. RIDEAL and W. E. YOULE.

SUBJOINED is a table giving the absolute viscosity of various gums. A comparison of the uncorrected viscosities with the corrected shows the great importance of Slotte's correction for dextrins and inferior gum arabics; in other words, for solutions of low viscosity, while it will be observed to have little influence upon the uncorrected η obtained for the Ghatti gums and the best samples of gum arabic.

TABLE OF ABSOLUTE VISCOSITIES OF 10 PER CENT. GUM AND DEXTRIN SOLUTIONS.

Sample.	η Uncorrected.	η Corrected.	Z Water = 100.
Gum arabic	0·1876	0·1820	1,233
Cape gum	0·1575	0·1555	1,029
Indian gum	0·0540	0·0470	311
Eastern gum	0·0680	0·0630	417
Gum arabic	0·0550	0·0480	317
Senegal	0·0494	0·0410	271
Senegal	0·0468	0·0380	251
Senegal	0·0627	0·0557	364
Gum arabic	0·0511	0·0430	285
Water	0·0149	0·0124	100
Ghatti	0·2903	0·2880	2,322
Ghatti, 5 per cent.	0·0903	0·0828	668
Ghatti, 5 per cent.	0·1301	0·1350	1,089
Ghatti, 5 per cent.	0·1795	0·1760	1,420
Ghatti, 5 per cent.	0·1527	0·1485	1,198
Ghatti, 5 per cent.	0·1130	0·1083	873
Ghatti, 5 per cent.	0·1419	0·1369	1,104
Dextrin	0·0398	0·0255	169
Dextrin	0·0341	0·0196	129
Dextrin	0·0455	0·0380	306
Gum substitute	0·0318	0·0224	180
Gum substitute	0·0318	0·0224	180
Amrad	0·0798	0·0708	570
Australian	0·0378	0·0283	228
Australian	0·0365	0·0268	216
Brazilian	0·0688	0·0627	506
Brazilian	0·0516	0·0445	359
Ghatti	0·3636	0·3621	2,920

In the column for η corrected the differences due to the use of different instruments are of course eliminated. The absolute viscosity of water at 15° C. determined in four different instruments is shown below. Poiseuille's value for water being 0·0122.

Instrument.	1.	2.	3.	4.
η corrtd. of water.	0·0109	0·01185	0·0124	0·0120
K value	0·00000898	0·00000863	0·00000882	0·0000052
K_1 value	0·235	0·2175	0·226	0·204

The above values for various gums and dextrins were obtained at a constant temperature of 15° C. and are compared with water at that temperature. It is of the utmost importance that the temperature of the water surrounding the bulbs should be adjusted for each series of experiments to the temperature at which the absolute viscosity of the water was determined. As far as we have ascertained, in gum solutions there is a steady diminution in viscosity with increase of temperature until a certain temperature is reached, beyond which increase of heat does not markedly influence the viscosity, and it is possible that above this "critical point," as we may term it, the gum solutions once more begin to increase in viscosity. The temperature at which the viscosity becomes stationary varies somewhat with different gums, but broadly speaking it lies between 60° C. and 90° C., no gums showing any marked decrease in viscosity between 80° C. and 90° C.

The experiments we have made in this direction were conducted as follows. The 300 c. c. bottle containing the gum was placed in a capacious beaker full of hot water, and the viscosity instrument was also surrounded with water at the same temperature. Thermometers were suspended both in the beaker and the outer jar. The viscosity at the highest temperature obtained, about 90° C., was then taken and repeated for every fall of 4° C. till the water reached the temperature of the air.

The values so obtained gradually diminished with the increase of temperature. From the η values obtained the Z values were calculated, using water at 15° C. as a standard. From the Z values thus obtained taken as the ordinate, and the temperature of each experiment as the abscissa, curves were plotted out embodying the results, examples of which are given below. The curves yielded by three gums 2, 7, and 8 changed between 90° C and 100° C., while gum sample 4 has a curve bending between 60° C. and 70° C. Experimentally this increase of viscosity of the latter gum above 60° C. was confirmed, but the critical point of the other solutions tried approaches too nearly to the boiling point of water for experiments to be conducted with accuracy, as the temperature of the bulbs diminishes sensibly while the experiment is being made.

If viscosity values have been determined it is possible to calculate the remaining or intermediate values for Z at any particular temperature from the general equation— $Zt = A + Bt + Ct^2$

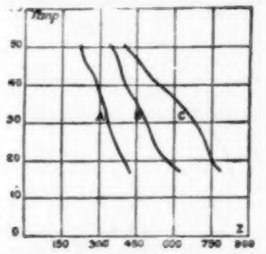
As an example of the mode of calculation we may quote the following. A gum gave the following values for Z at the temperature stated:

Gum............ 50° C. $Z_{50°} = 228$
Gum............ 30° C. $Z_{30°} = 339$
Gum............ 20° C. $Z_{20°} = 412$

from which the constants—

$A = 592·99 \quad B = -10·2153 \quad C = 0·0583$

can be obtained, and thus the value of $Z_{t°}$ for any required temperature. The numbers calculated for gums all point to a diminution in viscosity up to a certain point, and then a gradual increase. A comparison of some of the figures actually obtained in some of these experiments, with the calculated figures for the same temperature, shows their general agreement.



Curves showing viscosity change with temperature for three typical gums. A—Arabic VII. B—Senegal VIII. C—Ghatti 15.

EFFECT OF TEMPERATURE UPON VISCOSITY—GUM VII.

Temperature.	η	Z found.	Z calculated.
° C.			
50	0·0283	228	228·00
46	0·0305	246	246·55
42	0·0352	284	266·75
38	0·0368	297	289·00
34	0·0410	330	313·06
30	0·0419	339	339·00
26	0·0445	359	367·80
22	0·0492	398	396·47
20	0·0511	412	412·00
18	0·0531	428	428·00

EFFECT OF TEMPERATURE UPON VISCOSITY.—GUM VIII.

Temperature.	η	Z found.	Z calculated.
° C.			
50	0·0430	347	347
46	0·0475	383	371·14
42	0·0502	405	397·09
38	0·0510	411	424·73
34	0·0575	463	454·06
30	0·0602	485	485
26	0·0637	513	517·82
22	0·0667	538	552·25
20	0·0707	570	570
18	0·0755	609	583·07

The constants for the first gum are those given in the preceding column, while for the latter they were—

$A = 771·9 : B = -11·15 : C = 0·053$

As will be observed, the effect of heat appears to be the same upon the two typical gum arabics quoted above, an increase of temperature from 18° C. to 50° C. decreasing the viscosity by nearly one half in both cases, and the same seems to be true of most gum arabics. Roughly also the same holds good for Ghattis, as the following numbers show:

Gum.	Z at 18° C.	Z at 50° C.
Gum arabic	1016	879
Gum arabic	428	228
Gum arabic	609	347
Gum arabic	581	238
Ghatti	572	306
Ghatti	782	418

The following table shows the effect of heat upon the viscosity of a typical Ghatti:

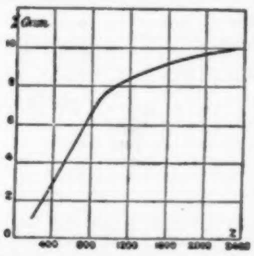
GHATTI GUM No. 15.—VISCOSITY.

Temperature.	η	Z.
° C.		
50	0·0517	418
46	0·0581	468
42	0·0628	506
38	0·0725	585
34	0·0788	635
30	0·0857	691
26	0·0889	717
22	0·0919	741
20	0·0946	763
18	0·0964	777

There is therefore no essential difference in the behavior of a Ghatti and a gum arabic on heating. Some interesting results, however, were obtained by heating gums, both Ghattis and arabics, at a fixed temperature for the same time, cooling, and then after making the solutions up to the original volume taking their viscosities at the ordinary temperature. The effect of heating for two hours to 60° C., 80° C., or 100° C. was a small permanent alteration in viscosity of the solution, and it would therefore seem desirable that gum solutions should be made up cold to get the maximum results. The following numbers illustrate this change, viz.:

Gum Arabic 10 Per Cent.	Without heat.	After heating to		
		60° C.	80° C.	100° C.
Z at 18° C.	570	463	470	517
Z at 30° C.	485	400	422	439
Z at 50° C.	347	287	258	304
Ghatti gum No. 15, 5 per cent. Z at 18° C.	1,104	780	699	738

The variation of viscosity with strength of solution was also studied with one or two typical gums. A 10 per cent. is invariably more than twice as viscous as a 5 per cent. solution. The following curve was obtained from one of the Ghattis. Similar results were shown by other gums.



Variation of Viscosity, with Dilution.
Ghatti No. 888.

It would seem, therefore, that strong solutions, say of 50 per cent. strength, would be more alike in viscosity than solutions of 5 per cent. strength of the same gums. In other words, the viscosity of a gum solution should be taken as nearly as possible to the strength it is used at, to obtain an exact quantitative idea of its gumming value.

The observation of this fact was one of the circumstances which decided us to use 5 per cent. solutions for the determination of Ghatti gum viscosities, the ratio between the 5 per cent. and 10 per cent. solutions of gum arabics being roughly the same as that between the respective weights required for gumming solutions of equal value.

From observation of the general nature of the solutions of Ghatti gums, and from the fact that when allowed to stand portions of the apparently insoluble matter passed into solution, the hypothesis suggested itself that metarabin was soluble in arabin, although insoluble in cold water. If this hypothesis were correct, it would explain the apparent anomaly of Ghattis giving solutions of higher viscosity than gum arabics, although they leave insoluble matter behind. The increase in viscosity would be due to the thickening of the arabic acid by the metarabin. Moreover, the solutions yielded by various Ghattis leaving insoluble matter behind would *be all of the same kind*, viz., a saturated solution of metarabin in arabin more or less diluted by water. Still further, if the insoluble residue of a Ghatti be the residual metarabin over and above that required to saturate the arabin, then it will be possible to dissolve this by the addition of more arabin in the form of ordinary gum arabic. In order to see if this were the case the following experiments were performed. Equal parts of a Ghatti and of a gum arabic were ground up together and dissolved in water. The resulting solution was *clear*. It was diluted until of 10 per cent. strength, and its viscosity then taken:

—	Contains 50 per Cent. Ghatti.	
A. Pressure 299 mm.	η	Z.
Temperature 15° C.	0·2517	2,020

The viscosity of this solution therefore was considerably greater than the mean viscosity of the 10 per cent. solutions of the Ghatti and the gum arabic, viz.,

$$\frac{0·288 \quad 0·0636}{2} = 0·1758$$ for the calculated η. Hence it is evident that the increase in viscosity is due to the solution of the metarabin.

Next a solution was made from a mixture of 70 per cent. Ghatti and 30 per cent. gum arabic. This was also clear and gave a considerably higher viscosity than the previous solution.

—	Contains 70 per Cent. Ghatti.	
B. Pressure 290 mm.	η	Z
Temperature 15° C.	0·3177	2,563

It will be obvious that the increase of viscosity over the previous solution in this case must be due to the smaller amount of the thin gum arabic which is present, *i. e.*, in the first case there is more gum arabic than is required to dissolve the whole of the insoluble metarabin. Further experiments showed that this is also true of the second mixture, as the viscosities of the following mixtures illustrate:

* A paper read before the Society of Chemical Industry, London, 1891. From the Journal.

Strength of Solution.	η	Z.
C. 80 per cent. Ghatti	0·3642	2,937
D. 75 per cent. Ghatti	0·33098	2,669
E. 77·5 per cent. Ghatti	0·4860	3,919

This last solution E we called for convenience the "maximum viscosity" solution, as we believe it to be a 10 per cent. solution containing arabin very nearly saturated with metarabin. As will be observed, its viscosity differs widely from those of solutions C and D, between which it lies in percentage of Ghatti. The first named solution C contains *too little* of gum arabic to dissolve the whole of the metarabin. Consequently there is a residue left undissolved, which of course diminishes its viscosity. The second solution D is too low in viscosity, as it still contains too much of the weak gum arabic, and as will be seen further on, a very slight change in the proportions increases or decreases the viscosity enormously.

We next tried a series of similar experiments with a Ghatti containing far less insoluble residue and which consequently would require less gum arabic to produce a perfect solution. Mixtures were made in the following proportions, viz.:

—	13·3 per Cent. Ghatti.	
F. Pressure 200 mm.	η	Z.
Temperature 15° C.	0·0976	787

—	86·6 per Cent. Ghatti.	
G. Pressure 200 mm.	η	Z.
Temperature 15° C.	0·4336	3,497

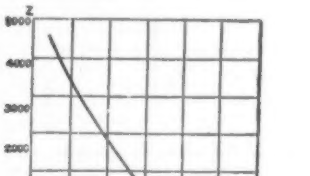
This latter solution is approaching fairly closely to our "maximum viscosity" with the previous Ghatti, and probably a very slight decrease in the amount of gum arabic would bring about the required increase in viscosity.

When these experiments were first commenced we were still under the impression, which several months' experience of working with gums had produced, namely, that the Ghattis were quite distinct in their properties to ordinary gum arabics. But the new hypothesis, and the experiments undertaken to confirm it, showed clearly that if the viscosity of a gum solution depends on the ratio of metarabin to arabin, then there is no absolute line of demarkation between a Ghatti and a gum arabic. In other words, there is a constant gradation between gum arabic and Ghattis, down to such gums as cherry gum, consisting wholly of metarabin and quite insoluble in water. Therefore those gum arabics which are low in viscosity consist of nearly pure arabin, while as the viscosity increases so does the amount of metarabin, until we come to Ghattis which contain more metarabin than their arabin can hold in solution, when their viscosity goes down again.

From these observations it would follow, that by taking a gum of less viscosity than the gum arabic previously used to dissolve the Ghatti, less of it would be required to do the same work. We confirmed this suggestion experimentally by taking another gum arabic of viscosity 0·0557 at 15° C. A mixture containing 93·3 per cent. of this Ghatti and 6·7 per cent. of our thinnest gum arabic gave a clear solution which had the highest viscocity we have yet obtained for a 10 per cent. solution.

H. Pressure 200 mm.	η	Z.
Temperature 15° C.	0·5525	4,456

This gum arabic may be regarded as nearly pure arabin (as calcium and potassium, etc., salt). By diluting the new "maximum viscosity" solution, therefore, with the 10 per cent. solution of the gum arabic in fixed proportions we obtain a series of viscosites which are shown in the following curve.



Curve Showing Influence of Ghatti upon Viscosity.

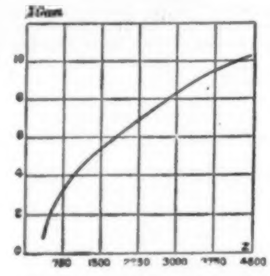
Besides obtaining this curve for change in viscosity from maximum amount of metarabin to no metarabin at all, we also traced the decrease in viscosity of the "maximum" solution by dilution with water. The following numbers were thus obtained, and plotted out into a curve.

Having obtained this curve, we are now in a position to follow up the hypothesis by calculating the surplus amount of insoluble matter in a Ghatti. For, let it be conceded that the solution of any Ghatti leaving an insoluble residue is a mixture of arabin and metarabin in the same ratio as our "maximum" solution, only more diluted with water, then from the found viscosity we obtain a point on the curve for dilution, which gives the percentage of dissolved matter.

Now to show the use of this: The Z value for a 10 per cent. solution of the second Ghatti at 15° C. is 2,940. This corresponds on the curve to 8·4 dissolved matter. 10–8·4=1·6 grammes in 10 grammes, which is insoluble.

CHANGE OF VISCOSITY WITH DILUTION – "MAXIMUM" SOLUTION. 15° C. TEMPERATURE.

Percentage.	η	Z.
10	0·55250	4,456
9	0·42850	3,456
8	0·35120	2,832
7	0·27600	2,230
6	0·22290	1,797
5	0·16810	1,355
4	0·11842	955
3	0·08023	647
2	0·06190	499
1	0·03610	291



Curve of Variation in Viscosity on Dilution of the "Maximum" Solution.

We have already shown that a "maximum" viscosity solution of this gum is formed when 6·7 per cent. of thin gum arabic is added to it, and therefore 6·7 parts of a thin gum arabic are required to bring 16 parts of metarabin into solution. A convenient rule, therefore, in order to obtain complete solution of a Ghatti gum is to add half the weight in thin gum of the insoluble metarabin found from the viscosity determination. But the portion of the gum which dissolved is made up in a similar manner (being a diluted "maximum" solution).

Therefore the 84 per cent. of soluble matter contains 58 parts of metarabin, and the total metarabin in this gum is 58 + 16 = 74 per cent. on the dry gum.

With these solutions of high viscosity some other work was done which may be of interest. The temperature curves of the mixtures marked E, G, and F were obtained between 60° C. and 15° C. The two former curves showed a direction practically parallel to that at the 10 per cent. solutions, and as they were approaching to the "maximum" solution, this is what one would expect. Mr. S. Skinner, of Cambridge, was also good enough to determine the electrical resistances of these solutions and the Ghattis and gum arabics employed in their preparation. The electrical resistance of these gum solutions steadily diminishes as the temperature increases, and the curve is similar to those obtained for rate of change with temperature. Although the curves run in, roughly, the same direction, there does not appear to be any exact ratio between the viscosities of two gums say at 15° C. and their electrical resistances at the same temperature; hence it would not seem possible to substitute a determination of the electrical resistance for the viscosity determination. The results appear to be greatly influenced by the amount of mineral matter present, gums with the greatest ash giving lower resistances.

Experiments were conducted with two Ghattis and two gum arabics, besides the mixtures marked E, F, and H. Comparison of the electrical resistances with the viscosities at 15° C. shows the absence of any fixed ratio between them.

Gum or Mixture.	° C.	Ohms Resistance.	Z Viscosity at 15° C.
Ghatti, 1	10	5,667	1,490
Ghatti, 2	15	2,220	2,940
Arabic 1	15	1,350	605
Arabic 2	10	2,021	449
Mixture F	15	1,930	787
Mixture E	11·3	2,058	3,919

While performing these experiments, an attempt was made to obtain an "ash-free" gum, in order to compare its viscosity with that of the same gum in its natural state. A gum low in ash was dissolved in water, and the solution poured on to a dialyzer, and sufficient hydrochloric acid added to convert the salts into chlorides. When the dialyzed gum solution ceased to contain any trace of chlorides, it was made up to a 10 per cent. solution, and its viscosity determined under 100 mm. pressure, giving the following results at 15° C.:

—	η	Z
Natural gum	0·05570	449
"Ash-free" gum	0·05431	438

Thus showing that the viscosity of pure arabin is almost identical with that of its salts in gum.

The yield of furfuraldehyde by the breaking down of arabin and metarabin was thought possibly to be of some value in differentiating the natural gums from one another, but we have not succeeded in obtaining results of much value. 0·2 gramme of a gum were heated with 100 c. c. of 15 per cent. sulphuric acid for about 2½ hours in an Erlenmeyer flask with a reflux condenser. After this period of time, further treating did not increase the amount of furfuraldehyde produced. The acid liquid, which was generally yellow in color, was then cooled and neutralized with strong caustic soda. The neutral or very faintly alkaline solution was then distilled almost to dryness, when practically the whole of the furfuraldehyde comes over. The color produced by the gum distillate with aniline acetate can now be compared with that obtained from some standard substance treated similarly. The body we have taken as a standard is the distillate from the same weight of cane sugar. The tint obtained with the standard was then compared with that yielded by the gum distillate from which the respective ratios of furfuraldehyde are obtained. The following table shows some of these results:

Substance.	Comparative Yield of Furfuraldehyde.	Amount of Glucose Produced.
Cane sugar	1·00	..
Starch	0·50	..
Gum arabic	1·33	34·78
Gum arabic	1·20	43·65
Ghatti, 1	1·00	26·78
Ghatti, 2	1·33	22·86
Metarabin	1·75	..

The amount of reducing sugar calculated as glucose is also appended. This was estimated in the residue left in the flask after distillation by Fehling's solution in the usual way. The yields of furfuraldehyde would appear to have no definite relation to the other chemical data about a gum, such as the potash and baryta absorptions or the sugar produced on inversion.

The action of gum solutions upon polarized light is interesting, especially in view of the fact that arabin is itself strongly lævo-rotatory $[\alpha]_D = -99°$, while certain gums are distinctly dextro-rotatory. Hence it is evident that some other body besides arabin is present in the gum. We have determined the rotatory power of a number of gum solutions, the results of which are subjoined. On first commencing the experiments we experienced great difficulty from the nature of the solutions. Most of them are distinctly yellow in color and almost opaque to light, even in dilute solutions such as 5 per cent. We found it necessary first to bleach the gums by a special process; 5 grammes of gum are dissolved in about 40 c. c. of lukewarm water, then a drop of potassium permanganate is added, and the solution is heated on a water bath with constant stirring until the permanganate is decomposed and the solution becomes brown. A drop of sodium hydrogen sulphate is now added to destroy excess of permanganate. At the same time the solution bocomes perfectly colorless.

It can now be cooled down and made up to 100 c. c., yielding a 5 per cent. solution of which the rotatory power can be taken with ease. Using a 200 mm. tube and white light the above numbers were obtained.

Gum or Dextrin.	Solution used.	$[\alpha]_j$.
	Per Cent.	
Aden, 1	5	− 33·8
Cape, 2	5	+ 28·6
Indian, 3	5	+ 66·2
Eastern, 4	5	− 26·0
Eastern, 5	5	− 30·6
Senegal, 6	5	− 17·6
Senegal, 7	5	− 18·4
Senegal, 8	2½	− 19·6
Senegal, 9	5	− 38·2
Senegal, 10	5	− 25·8
Amrad	2½	+ 57·6
Australian, 1	5	− 28·2
Australian, 2	5	− 26·4
Brazilian, 1	2½	− 36·8
Brazilian, 2	2½	+ 21·0
Dextrin, 1	5	+148·0
Dextrin, 2	5	+133·2
Ghatti, 1	5	− 39·2
Ghatti, 2	5	− 80·4

These numbers do not show any marked connection between the viscosity, etc., of a gum and its specific rotatory power.

When gum arabic solution is treated with alcohol the gum is precipitated entirely if a large excess of spirit be used. With a view to seeing if the precipitate yielded by the partial precipitation of a gum solution was identical in properties to the original gum, we examined several such precipitates from various gums to ascertain their rotatory power. We found in each case that the specific rotatory power of the alcohol precipitate redissolved in water was not the same as that of the original gum. In other words these gums contained at least two bodies of different rotatory powers, of which one is more soluble in alcohol than the other. O'Sullivan obtained similar results with pure arabin. The experiments were conducted in the following manner:

(*a*.) Five grammes of a dextro-rotatory gum (No. 3 in table) were dissolved in 20 c. c. of water. To the solution was added 90 c. c. of 95 per cent. alcohol. The white precipitate which formed was thrown on to a tared filter and washed with 30 c. c. more alcohol. The total filtrate therefore was 140 c. c. The precipitate was dried and weighed = 2·794 grammes or 55·88 per cent. of the total gum. The precipitate was then redissolved in water, bleached as before and diluted to a 5 per cent. solution. This was then examined in the polarimeter. Readings gave the value $[\alpha]_j = +58·4°$. The previous rotatory power of the gum was $+66°$. Now the alcohol was driven off from the filtrate, which, allowing for the 11·95 per cent. of water in the gum, should contain 32·17 per cent. of gum. The alcohol-free liquid was then diluted to a known volume

(for 5 per cent. solution), and $[\alpha]_j$ found to be $+ 57·7°$. This experiment was then repeated again, using 5 grammes of No. 3, when 3·5805 grammes of precipitate were obtained, using the same volumes of alcohol and water. The precipitate gave $[\alpha]_j = + 57·4°$; the filtrate treated as before, only the percentage of gum dissolved being directly determined instead of being calculated by difference, gave $[\alpha]_j = + 52·5°$.

(b.) Another gum (No. 9) with $[\alpha]_j = - 38·2°$ and containing 13·86 per cent. of moisture, gave 2·3315 grms. of precipitate when similarly treated. The precipitate gave when redissolved in water $[\alpha]_j = - 20·8°$. The filtrate containing 39·5 per cent. real gum gave $[\alpha]_j = - 67·5°$, so that the least lævo-rotatory gum was precipitated by the alcohol.

The Ghattis apparently are all lævo-rotatory, and give much less alcoholic precipitates than the gum arabic. The precipitation moreover was in the opposite direction, that is, the most lævo-rotatory gum was thrown down by the alcohol. The appended table shows the nature of the precipitates and the respective amounts from two Ghattis and two gum arabics. It will be observed that the angle of rotation in three of the cases is decidedly less both for precipitate and filtrate than for the original solution :

SPECIFIC ROTATORY POWERS OF GUMS.

Gum used.	Weight Gum Waken.	Weight Alcohol Precipitate.	Weight Gum Filtrate.	$[\alpha]_j$ original Gum.	$[\alpha]_j$ Alcohol Precipitate.	$[\alpha]_j$ Filtrate.
	Grms.					
3 { a	5	2·7940	1·9415	+ 66·2	+ 58·4	+ 53·7
3 { b	5	3·5805	0·8910		+ 57·4	− 52·5
9 { a	5	2·3315	2·3736	− 38·2	− 20·8	− 67·5
9 { b	4·9620	2·3310	2·4480		− 19·4	− 62·4
Ghatti { a....	3·4900	0·3925	2·7920	− 140·8	− 104·2	− 76·0
Ghatti { b ...	3·2450	0·4065	2·8385		− 106·0	− 72·4
Ghatti { a ...	2·2550	0·2900	1·8078	− 147·05	− 106·04	− 69·0
Ghatti { b ...	2·6835	0·2845	2·3360		− 102·04	− 66·2

The hygrometric nature of a gum or dextrin is a point of considerable importance when the material is to be used for adhesive purposes. The apparatus which we finally adopted after many trials for testing this property consists simply of a tinplate box about 1 ft. square, with two holes of 2 in. diameter bored in opposite sides. Through these holes is passed a piece of wide glass tubing 18 in. long. This is fitted with India rubber corks at each end, one single and the other double bored. Through the double bored cork goes a glass tube to a Woulffe's bottle containing warm water. A thermometer is passed into the interior of the tube by the second hole. The other stopper is connected by glass tubing to a pump, and thus draws warm air laden with moisture through the tube. Papers gummed with the gums or dextrins, etc., to be tested are placed in the tube and the warm moist air passed over them for varying periods, and their proneness to become sticky noted from time to time. By this means the gums can be classified in the order in which they succumbed to the combined influences of heat and moisture. We find that in resisting such influences any natural gum is better than a dextrin or a gum substitute containing dextrin or gelatin. The Ghattis are especially good in withstanding climatic changes.

Dextrins containing much starch are less hygroscopic than those which are nearly free from it, as the same conditions which promote the complete conversion of the starch into dextrin also favor the production of sugars, and it is to these sugars probably that commercial dextrin owes its hygroscopic nature. We have been in part able to confirm these results by a series of tests of the same gums in India, but have not yet obtained information as to their behavior in the early part of the year.

The fermentation of natural gum solutions is accompanied by a decrease in the viscosity of the liquid and the separation of a portion of the gum in lumps. Apparently those gums which contain most sugar, as indicated by their reduction of Fehling's solution, are the most susceptible to this change. Oxalic acid is formed by the fermentation, which by combination with the lime present renders the fermenting liquid turbid, and also some volatile acid, probably acetic.

We have made some experiments with a gum which readily fermented—in a week—as to the respective value of various antiseptics in retarding the fermentation. Portions of the gum solutions were mixed with small quantities of menthol, thymol, salol, and saccharin in alkaline solution, also with boric acid, sodium phosphate, and potash alum in aqueous solution. Within a week a growth appeared in a portion to which no antiseptic had been added ; the others remained clear. After over five months the solutions were again examined, when the following results were observed :

Antiseptics.	Solution after Five Months.
Menthol in KOH	Some growth at bottom, upper layer clear.
Thymol in KOH	Growth at top, gum white and opaque.
Salol in KOH	Growth at top, gum black and opaque
Saccharin in KOH ...	White growth at top.
Boric acid............	Remained clear ; did not smell.
Sodium phosphate ...	Slight growth at top.
Potash alum	Slight growth at top.

The solution to which no antiseptic had been added was of course quite putrid, and gave the reactions for acetic acid.

In the earlier part of this paper we have given a short account of the chief characteristics of the more important gum substitutes. The following additional notes may be of interest.

The ashes of most gum substitutes, consisting chiefly of dextrin, are characterized by the high percentage of chlorides they contain, due no doubt to the use of hydrochloric acid in their preparation. The soluble constituents of the ash consist of neutral alkaline salts, but as a rule no alkaline carbonates, and it is thus possible to demonstrate the absence of any natural gum in such a compound. We have seldom noticed the presence of any sulphates in such ashes, but when sulphurous or sulphuric acids have been used in the starch conversion it will be found in small quantities.

We have already pointed out that the potash absorption value of a gum is low and that dextrins give high numbers, but the latter vary very considerably, and as the starch and sugar present also influence the potash absorption value, it does not give information of much service. The following table shows the kind of results obtained :

Sample.	KOH absorbed.	Starch.	Real Gum.
		Per Cent.	Per Cent.
Dextrin, 1	25·40	1·99	..
Dextrin, 2	19·70	13·13	..
Dextrin, 3	7·57	24·72	..
Artificial gum, 1	19·70	10·98	9·06
Artificial gum, 2	13·70	8·05	23·50
Starch	9·43	100·00	None

The baryta absorptions seem to be chiefly due to the quantity of starch present in the composition :

Sample.	Starch.	BaO absorbed.
	Per Cent.	Per Cent.
Dextrin, 1	1·99	1·75
Dextrin, 2	13·13	3·53
Dextrin, 3	24·72	5·64
Starch..........................	100·00	23·61

The viscosity of a dextrin or artificial gum is determined in exactly the same way as a natural gum, using 10 per cent. solutions. It would probably be an improvement to use 10 per cent. solutions for many of the dextrins, as they are when low in starch extremely thin.

The hygroscopic nature of dextrins renders them unsuitable for foreign work, but when the quantity of starch is appreciable, better results are obtainable. A large percentage of unaltered starch is usually accompanied with a small percentage of sugar, and no doubt this is the explanation of this fact. An admixture containing natural gum of course behaved better than when no such gum is present. Bodies like "arabol" made up with water and containing gelatin are very hygroscopic when dry, although as sold they lose water on exposure to the air. Gum substitutes consisting entirely of some form of gelatin with water, like fish glue, are also somewhat hygroscopic when dried. The behavior of these artificial gums and dextrins on exposure to a warm moist atmosphere can be determined in the same apparatus as described for gums.

The process we have adopted for estimating the glucose starch and dextrin in commercial gum substitutes is based on C. Hanofsky's method for the assay of brewers' dextrins (this Journal, 8, 561). A weighed quantity of the dextrin is dissolved in cold water, filtered from any insoluble starch, and then the glucose determined directly in the clear filtrate by Fehling's solution. The real dextrin is determined by inverting a portion of the filtered liquid with HCl, and then determining its reducing power. The starch is estimated by inverting a portion of the solid dextrin, and determining the glucose formed by Fehling. After deducting the amounts due to the original glucose and the inverted dextrin present, the residue is calculated as starch. A dermination of the acidity of the solution is also made with decinormal soda, and results returned in number of c. c. alkali required to neutralize 100 grammes of the dextrin. Results we have obtained using this method are embodied in the following table :

ANALYSIS OF GUM SUBSTITUTES

No.	Glucose.	Dextrin.	Starch.	Moisture.	Gum, &c.	Ash.	Acidity.
							cc.
1	8·92	81·57	1·99	10·12	None	0·207	57·3
2	7·19	71·46	13·13	10·40	None	0·120	44·8
3	1·29	69·42	24·72	4·17	1·12	0·280	5·22
4	8·40	60·98	10·98	10·09	9·02	0·530	20·0
5	10·60	44·98	8·05	12·20	23·57	0·600	52·0
6	14·80	11·57	36·46	34·87	1·89	0 580	8·0
7	8·00	29·61	26·78	33·98	0·88	0·750	88·0
8	2·29	52·38	37·65	None	7·335	0·315	9·6

In those cases in which the substitute is made by admixture with gelatin or liquid glue the quantity of other organic matter obtained can be checked by a Kjeldahl determination of the total nitrogen. If a natural gum is added, it will be partially converted into sugar when the filtered liquid is inverted, and so make the dextrin determination slightly too high.

MR. CAILLETET'S CRYOGEN.

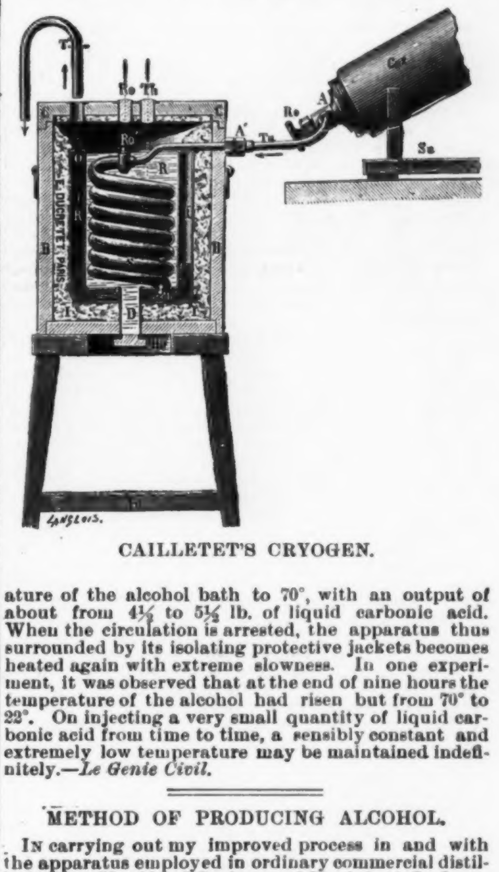
THE "cryogen," a new apparatus constructed by Mr. E. Ducretet, from instructions given by Mr. Cailletet, is designed for effecting a fall of temperature of from 70° to 80° C. below zero, through the expansion of liquid carbonic acid.

The apparatus consists of two concentric vessels having an annular space between them of a few centimeters. A worm, S, is placed in the internal vessel R. All this is of nickel plated copper. The worm, S carries, at Ro', an expansion cock and ends, at O in the annular space, R'. A very strong tube is fixed to the cock, Ro', and to the ajutage, A'. It receives the tube, Tu, which, at the time of an experiment, is coupled with the cylinder of carbonic acid, CO^2. A tubulure, D, usually closed by a plug, Bo, communicates with the inner receptacle, R. This is capable of serving in certain experiments in condensation. The table, Ta, of the tripod receives the various vessels or bottles for the condensed products.

The entire apparatus is placed in a box, B, lined with silk waste and provided with a cover, C, of the same structure. Apertures, Th, Ro, and T", allow of the passage of a key for acting upon the cock, Ro', as well as of thermometers and stirrers if they are necessary.

When it is desired to operate, the internal vessel, R, is filled with alcohol (3 quarts for the ordinary model). This serves as a refrigerant bath for the experiments to be made. The worm, S, having been put in communication with the carbonic acid cylinder, CO^2, the cock, Ro, of the latter is turned full on. The cock of the worm, which is closed, is opened slightly. The vaporization and expansion of the liquid carbonic acid cause it to congeal in the form of snow, which distributes itself and circulates in the worm, S, and then in R. The flakes thus coming in contact with the metallic sides of S rapidly return to the gaseous state and produce an energetic refrigeration. At the lower part of the annular space, R', are placed fragments of sponge impregnated with alcohol. The snow that has traversed the worm without vaporizing reaches R', and dissolves in this alcohol, and the refrigeration that results therefrom completes the lowering of the temperature. The gas finally escapes at O, and then through the bent tube, T".

The apparatus may be constructed with an inverse circulation, the carbonic acid then entering the annular vessel, R, directly, and afterward the worm, S, whence it escapes to the exterior of the apparatus. The expansion cock sometimes becomes obstructed by the solidification of the snow. It will then suffice to wait until the circulation becomes re-established of itself. It may be brought about by giving the cock, Ro', a few turns with the wooden handled key that serves to maneuver the latter. It is not necessary to have a large discharge of carbonic acid, and consequently the expansion cock needs to be opened but a little bit. A few minutes suffice to reduce the temperature of the alcohol bath to 70°, with an output of about from 4½ to 5¼ lb. of liquid carbonic acid. When the circulation is arrested, the apparatus thus surrounded by its isolating protective jackets becomes heated again with extreme slowness. In one experiment, it was observed that at the end of nine hours the temperature of the alcohol had risen but from 70° to 22°. On injecting a very small quantity of liquid carbonic acid from time to time, a sensibly constant and extremely low temperature may be maintained indefinitely.—*Le Genie Civil.*



CAILLETET'S CRYOGEN.

METHOD OF PRODUCING ALCOHOL.

IN carrying out my improved process in and with the apparatus employed in ordinary commercial distilleries, says Mr. Alfred Springer, of Cincinnati, O., I preferably employ separate vats or tubs for the nitric acid solution and the material to be treated, and a convenient arrangement is to locate the nitric acid tub directly under the grain tub, so that one may discharge into the other. In the upper vat is placed the farinaceous material, preferably ground, thoroughly steeped in three times its weight of water, and, where whole grain is used, preferably "cooked" in the ordinary manner. The vat into which the dilute acid is placed is an ordinary cooking tub of suitable material to resist the acid, provided with closed steam coils and also nozzles for the discharge of steam into the contained mass. Into this vat is placed for each one hundred parts of the grain to be treated one part of commercial nitric acid diluted with fifty parts of water and brought to a state of ebullition and agitation by the steam coils and the discharge through the nozzles, the latter being regulated so that the gain by condensation of steam approximately equals the loss by evaporation. The farinaceous contents of the upper vat are allowed to flow slowly into the nitric acid solution while the ebullition and agitation of the mass is continued. This condition is then maintained for six to eight hours, after which the mass is allowed to stand for one day or until the saccharification becomes complete. The conversion can be followed by the "iodine test" for intermediary dextrins and the "alcohol test" for dextrin. After the saccharification is complete I may partially or wholly neutralize the nitric acid, preferably with potassium or ammonium carbonate, preferably employing only one-half the amount necessary

to neutralize the original quantity of nitric acid used, so that the mass now ready to undergo fermentation has an acid reaction. The purpose in view here is to keep the peptones in solution also, because an acid medium is best adapted to the propagation of the yeast cells. It is not absolutely necessary to even partially neutralize the nitric acid, but it is preferable. Yeast is now added, and the remaining processes are similar to those generally employed in distilleries, excepting that just prior to distillation potassium carbonate sufficient to neutralize the remaining nitric acid is added, in order to avoid corrosion of the still and correct the acid reaction of the slop.

As a variant of the process I sometimes add to the usual amount of nitric acid an additional one one-hundredth part of phosphoric acid on account of its beneficial nutritive powers—that is to say, to one hundred parts of grain one part of nitric acid and one one-hundredth part of phosphoric acid.

While my improved process is based on the well-known converting power of acids on starch, I am not aware that it has ever been applied in the manner and for the purposes I have described. For example, sulphuric and hydrochloric, also sulphuric and nitric, acids have been employed in the manufacture of glucose; but in every such case the resulting products were not capable of superseding those obtained by the existing methods of saccharification used in distilleries. In my process, on the other hand, the product is so capable. Not only may malted grain be entirely omitted, but more fermentable products are formed and the products of fermentation are purer. The saccharification being more complete, there are less intermediary and nonfermentable dextrins, and the yield of spirits is therefore increased. Malted grain being omitted or used in reduced quantity, there is less lactic acid and few or foreign ferments to contaminate the fermenting mass; also, the formation of higher alcohols than the ethyl alcohol is almost totally suppressed. Consequently the final yield of spirits is purer in quality and requires little or no further purification. Also, further, the nitrates themselves acting as nutrients to the yeast cells, these become more active and require less nutrition to be taken from the grain.

SPECTROSCOPIC DETERMINATION OF THE SENSITIVENESS OF DRY PLATES.

AFTER describing other methods of determining the sensitiveness of plates, Mr. G. F. Williams, in the *Br. Jour. of Photo.*, thus explains his plan. I will now explain the method I adopt to ascertain the relative sensitiveness of plates to daylight. Procure a small direct vision pocket spectroscope, having adjustable slit and sliding focus. To the front of any ordinary camera that will extend to sixteen or eighteen inches, fit a temporary front of soft pine half an inch thick, and in the center of this bore neatly with a center bit a hole of such diameter as will take the eye end of the spectroscope; unscrew the eyehole, and push the tube into the hole in wood, bushing the hole, if necessary, with a strip of black velvet glued in to make a tight fit. By fixing the smaller tube in the front of camera we can focus by sliding the outer tube thereon; if we fix the larger tube in the front, we should have to focus inside the camera, obviously most inconvenient in practice. Place the front carrying the spectroscope *in situ* in the camera, and rack the latter out to its full extent; point the camera toward a bright sky, or the sun itself, if you can, while you endeavor to get a good focus. The spectrum will be seen on the ground glass, probably equal in dimensions to that of a quarter plate. Proceed to focus by sliding the outer tube to and fro until the colors are quite clear and distinct, and at same time screw down the slit until the Fraunhofer lines appear. By using the direct rays of the sun, and focusing carefully, and adjusting the slit to the correct width, the lines can be got fairly sharply. Slide your front so that the spectrum falls on the ground glass in just such a position as a quarter plate glass would occupy when in the dark slide, and arrange matters so that the red comes to your left, and the violet to the right, and invariably adopt that plan. It is advisable to include the double H lines in the violet on the right hand edge of your plate. They afford an unerring point from which you can calculate backward, finding G, F, E, etc., by their relative positions to the violet lines. Otherwise you may be mistaken as to what portion of the spectrum you are really photographing. The red should just be seen along the left edge of the quarter plate. When all is arranged thus, you utilize three-fourths of your plate with the spectrum, with just a little clear glass at each end. Before disturbing the arrangement of the apparatus, it is desirable to scratch a mark on the sliding tube, and make a memorandum of the position of all the parts, so that they may be taken away and replaced exactly and thus save time in future.

To take a photograph of the spectrum, put a quarter plate in the dark slide and place in camera; point the camera toward a bright sky, or white cloud, near the sun—not at the sun, as there is considerable difficulty in keeping the direct rays exactly in the axis of the spectroscope—draw the shutter, and give, say, sixty seconds. On development, you will probably obtain a good spectrum at the first trial. The duration of exposure must, of course, depend upon the brightness of the day; but if the experiments are to have relative values, the period of exposure must be distinctly noted, and comparisons made for a normal exposure of sixty seconds, ninety seconds, two minutes or more, just according to whatever object one has in view in making the experiments. With a given exposure the results will vary with the light and the width of the slit, as well as being influenced by the character of the instrument itself. Further, all such experiments should be made with a normal developer, and development continued for a definite time. The only exception to this rule would be in the event of wishing to ascertain the utmost that could be got out of a plate, but, under ordinary circumstances, the developer ought never to vary, nor yet the duration of development. To try the effect of various developers, or varying time in development, a departure must be made of such a nature as would operate to bring out upon each plate, or piece of a plate, the utmost it would develop short of fog, against which caution must be adopted in all spectrum experiments.

On development, say for one, two, or three minutes, wash off and fix. You will recognize the H violet lines and the others to the left, and this experiment shows what is the sensitiveness of this particular plate to the various regions of the spectrum with this particular apparatus, and with a normal exposure and development. So far, this teaches very little; it merely indicates that this particular plate is sensitive or insensitive to certain rays of colored light. To make this teaching of any value, we must institute comparisons. Accordingly, instead of simply exposing one plate, suppose we cut a strip from two, three, four, or even half a dozen different plates, and arrange them side by side, horizontally, in the dark slide, so that the spectrum falls upon the whole when they are placed in the camera and exposed. There is really no difficulty in cutting strips a quarter of an inch wide, the lengthway of a quarter plate. Lay the gelatine plate film up, and hold a straight edge on it firmly, so that when we use a suitable diamond we can plow through the film and cut a strip which will break off easily between the thumb and finger. A quarter plate can thus be cut up into strips to yield about a dozen comparative experiments. When cut and snapped off, mark each with pencil with such a distinguishing mark as shall be clearly seen after fixing. The cut up strips can be kept in the maker's plate box.

THE deep down underground electric railway in London has so far proved an unprofitable concern for its stockholders. It is 3½ miles long, touches some of the greatest points of traffic, but somehow or other people won't patronize it. The total receipts for the last six months were a little under $100,000, and they only carried seventeen persons per train mile. On this road the passengers are carried on elevators up and down from the street level to the cars. The poor results so far make the stockholders sick of the project of extending the road.

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PUBLISHED WEEKLY.

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